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THE ITALIAN CRUISER PIEMONTE.*

By Mr. P. WATTS, N.A., Member of Council.

THE Italian cruiser Piemonte has been constructed by the firm of Sir W. G. Armstrong, Mitchell & Co. This vessel is the latest of some dozen vessels of the protected cruiser class built by the same firm, including the Esmeralda, built in 1882–83, from the designs of Mr. George Rendel, and the Dogali, built in 1886, from the designs of Mr. White. Lord Armstrong, who has for several years past strongly advocated the construction of this class of war vessel, has enumerated as their chief features: "Great speed and nimbleness of movement combined with great offensive power," and "little or no side armor, but otherwise constructed to minimize the effect of projectiles;" and in designing the Piemonte I have sought to develop these features as much as possible, observing that the displacement was not to exceed 2,500 tons and the speed was not to fall short of 21 knots.

The principal dimensions, weights, etc., of the Piemonte are given herewith, and in Figs. 1, 2, and 3, the midship section, profile, and plans are shown.

Length, 300 feet; breadth, 38 feet; draught—fore, 14 feet; aft, 16 feet; displacement, 2,500 tons; I. H. P., 11,600; speed, 21¼ knots. Armament—Six 6 inch rapid firing guns; six 12 cm. rapid firing guns; ten 6 pounder rapid firing guns; six 1 pounder rapid firing guns; four Maxims (10 mm.); three torpedo guns. Weights—Hull and fittings, 970 tons; protective material, 280 tons; equipment, 130 tons; machinery and spars, 720 tons; coals† (normal), 200 tons; armament, 200 tons; total, 2,500 tons. Protective deck—Thickness on slopes, 3 inches; thickness on slopes, horizontal parts, 1 inch; conning tower, 8 inches.

She is 300 feet long, 38 feet broad, and 15 feet mean draught, and her displacement is 2,500 tons. She has a protective deck with sloping sides from stem to stern, which is 1 inch thick along the middle and 3 inches thick on the slopes. Her armament consists of six 6 inch quick firing guns, six 4¾ inch do., ten 6 pounder Hotchkiss guns, six 1 pounder do., four 10 mm. Maxim guns, and three torpedo tubes; and her speed is upward of 21 knots. Four of the 6 inch guns and the six 4¾ inch guns are carried upon the upper deck, the 6 inch guns being sponsoned out so as to enable the two foremost to fire right ahead and the two aftermost to fire right astern; one of the remaining 6 inch guns is placed on the forecastle, and the other on the poop. All of these guns have considerable arcs of training, as indicated upon the plan of weather deck, Fig. 3. Four of the 6 pounder quick firing guns have right ahead fire; two of these are placed under the forecastle, and two upon the after end of the forecastle; and four of these guns have right aft fire, two being placed under the poop and two upon the fore end of the poop. The other two 6 pounders and two of the 1 pounders are placed on the topsides. Each of the two lower tops carries two 1 pounder Hotchkiss guns, and each of the two upper tops two 10 mm. Maxim guns. One of the torpedo tubes fires directly ahead, and one on each broadside from a torpedo chamber immediately before the machinery spaces. I may remark that provision was also made in the design for a torpedo chamber immediately abaft the machinery space, provided with a torpedo tube on each broadside, and also for a torpedo tube at the stern firing right aft, but the Italian Admiralty have recently dispensed with these, accepting other armament weights in exchange for them.

This distribution of the gun armament has great advantages; it has been followed in most of the cruisers built by Sir W. G. Armstrong, Mitchell & Co., including those built before the Esmeralda. The guns upon the poop and forecastle have considerable arcs of training on each broadside without interfering with the fire of any of the other guns. Four 6 inch guns, three 4¾ inch guns, five 6 pounder Hotchkiss guns, five 1 pounder Hotchkiss guns, and four 10 mm. guns can be brought to bear upon an enemy on either broadside; and three 6 inch guns, four 6 pounder Hotchkiss guns, two 1 pounder Hotchkiss guns, and two 10 mm. Maxim guns can be brought to bear upon an enemy either right ahead or right astern. The 6 inch and the 4¾ inch guns are provided with 4½ inch steel shields for protecting the gunners; and all of the other guns carry light shields for the same purpose.

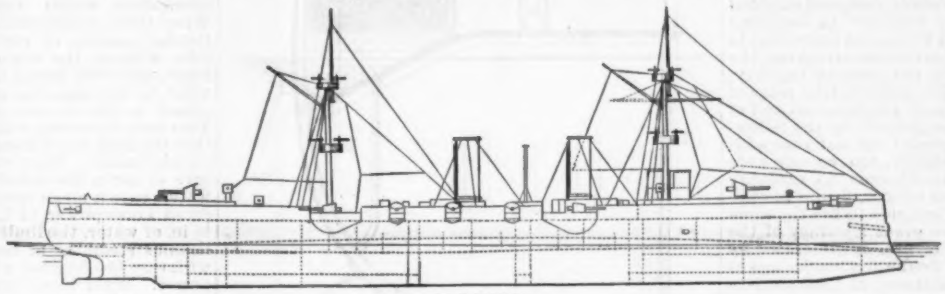


Fig. 2—PROFILE

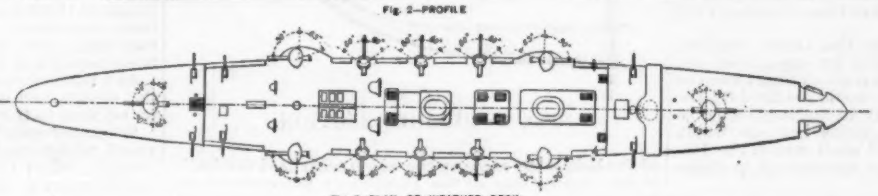


Fig. 3—PLAN OF WEATHER DECK.

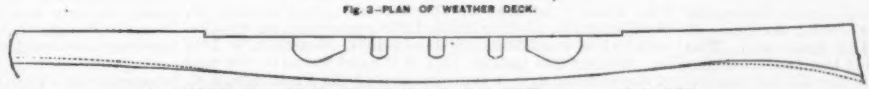
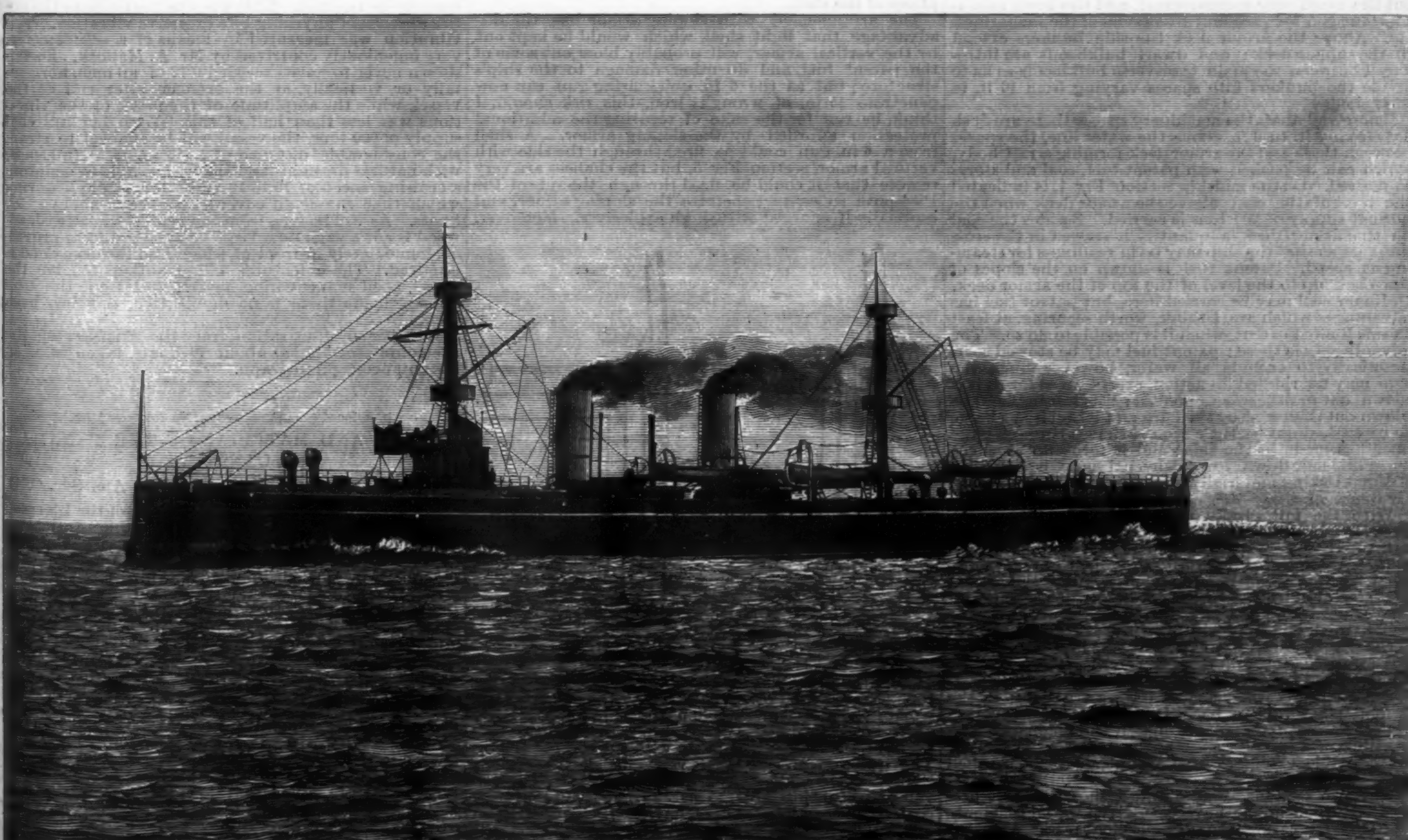


Fig. 4—PROFILES OF WAVES AGAINST SIDE OF SHIP AT 20 KNOTS —— AT 21 KNOTS ......

* Read at the Thirtieth Session of the Institution of Naval Architects.—*The Engineer.*

† Bunker space is provided in the ship for 600 tons of coal.



THE NEW ITALIAN CRUISER PIEMONTE.

The Piemonte is the first vessel armed with the new Elswick quick firing gun, all of the 6 inch and 4¾ inch guns being of this pattern. Lord Armstrong, in speaking of this gun recently, said: "The advantage of being able to fire rapidly at critical moments must be obvious to all. In the first place, the increased rapidity of the fire of each gun is tantamount to increasing the number of guns, without necessitating a corresponding increase in the number of gunners or in the collective weight of the shields required to protect them. In the second place, we obtain the great advantage of being able to repeat a successful shot before the enemy can materially change his position, which would render necessary a fresh adjustment of the gun. These salient advantages have been fully realized in our new guns of 4¾ inch and 6 inch caliber, with both of which a rapidity of fire has been attained hitherto considered impossible with guns of so heavy a nature. Great simplicity of design and strength of mechanism have been combined in the construction of these guns and their carriages; and with the improved descriptions of powder now coming into use, velocities have been obtained so great that the 4¾ inch gun, weighing only 3 tons 1 cwt., is capable of piercing 10¼ inches of wrought iron, while the 6 inch gun, weighing 5 tons 15 cwt., can pierce 15 inches of the same material, muzzle velocities being taken in each instance. These guns are mounted on specially designed shielded carriages, in which exceptional facilities in handling and aiming have been combined with great protection to the gunners, and in the numerous trials carried out the shooting has been characterized not only by rapidity, but by unusual accuracy. The comparative rates of fire of the present breech-loading service guns and of our new improved guns may be judged by the following instances: In some trials carried out last year with our 4¾ inch gun by the Admiralty, ten rounds were actually fired in 47½ seconds, whereas an ordinary breech-loading gun of the same caliber, firing in competition, took 5 minutes and 7 seconds to fire the same number of rounds. Again, the great accuracy of the guns, combined with rapidity of fire, is illustrated by the fact that five rounds were fired a few weeks ago at Shoeburyness, in which at a distance of 1,300 yards a target of 6 feet square was hit five times running in 31 seconds."

Speaking of the Piemonte on the same occasion, Lord Armstrong said: "She will be capable of discharging against an adversary in a given time twice the weight of shot and shell that could be fired by the largest war vessel now afloat, not excluding the leviathan battleships of five or six times her size, which could ill withstand the torrent of shell which the Piemonte could pour into the large unarmored portions of their structure."

The engines and boilers are wholly below the water line, and protected by the armor deck; so also, of course, are the magazines, steering gear, etc. The level of the armor deck throughout the length of the ship is shown on the profile, Fig. 2, the dotted line indicating the deck at middle, and the through line the deck at side. All apertures through the armor deck which would require to be opened in action are provided with cofferdams rising 4 ft. above water, and all openings are fitted with armor covers or armor bars. Both below and above the armor deck the ship is subdivided into a large number of water tight compartments. Each set of engines is in a separate compartment, and each pair of boilers is in a separate compartment.

There is a series of water tight flats forming an inner bottom throughout the ship, except in wake of the boiler compartments and the crank pits in the engine rooms. There are coal bunkers along the side throughout the machinery compartment, and the inner skin is continued on forward and aft as sides of the magazines, etc. Above the armor deck the side bunkers extend to the upper deck; and dwarf bulkheads are introduced between the main transverse bulkheads so as to divide the bunkers into spaces varying from 10 ft. to 12 ft. long.

Before and abaft the machinery spaces there are deck flats from 2 ft. to 3 ft. above the water line, the spaces between these and the armor deck forming a raft body, which can be packed with patent fuel, coal and stores as desired. On the midship section, Fig. 1, is indicated the level of the coal above the armor deck when the normal supply of 200 tons is carried. Besides the coal on the armor deck, a quantity is stowed in the cross bunkers, so that the ship may be in readiness for steaming at speed. Patent fuel is shown on the slopes of the deck up to the level of the top of the armor deck. Ordinary coal may be carried here, but patent fuel has advantages which are, I think, worth securing, at least to this limited extent, when it is possible to do so. The advantages are these: patent fuel may be stowed so as practically to exclude all water, however much the side may be riddled in action, except in so far as it is blown out or otherwise removed; it is less liable to be blown out than coal by shell fire and is much less liable to be washed out by the action of the sea through large openings made in the side; and it forms an excellent shoveling flat, down to which coal may be removed without risking materially loss of buoyancy and stability in action.

With the full supply of coal, the top of the armor deck is 6 in. below the water line; but part of this full supply may consist of patent fuel or coal in sacks stowed upon the armor deck to a depth of say 2 ft., thus forming a continuation of the raft body forward and aft; and this fuel need not be disturbed until, by the consumption of the coal from elsewhere, the ship is lightened, and the deck armor is raised above the water. If at the deep draught, with the assistance of the cofferdams, large volumes of water can be prevented from getting below—which is not likely to be difficult, seeing that any water finding its way to holes in the cofferdams will have but little head—and supposing the armor deck to remain intact, the buoyancy and stability of the ship may be regarded as to a very considerable extent assured even against modern shell fire.

The two sections, Figs. 5 and 6, show the belt protection which might have been given to the Piemonte without increasing the displacement; Fig. 5 on the supposition that the weight of the patent fuel is put into armor, and consequently the normal supply of fuel reduced by 100 tons; and Fig. 6 on the supposition that 200 tons of coal are carried as at present. The protection afforded in the case of Fig. 6 arrangement is much less than that afforded in the case of Fig. 5, but the ship provided with Fig. 6 arrangement would always have as her normal supply of coal the same quantity as the Piemonte has for ordinary sea-going purposes in peace time; while the ship provided with Fig. 5 arrangement would only have as her normal supply the quantity of coal which the Piemonte would be free to burn without touching the fuel which might aid her materially in action.

We will compare the protection afforded by the Fig. 5 belt arrangement with that afforded by the arrangement adopted in the Piemonte, shown in section on the midship section, Fig. 1. In each of these cases the horizontal deck is of the same thickness, and the width

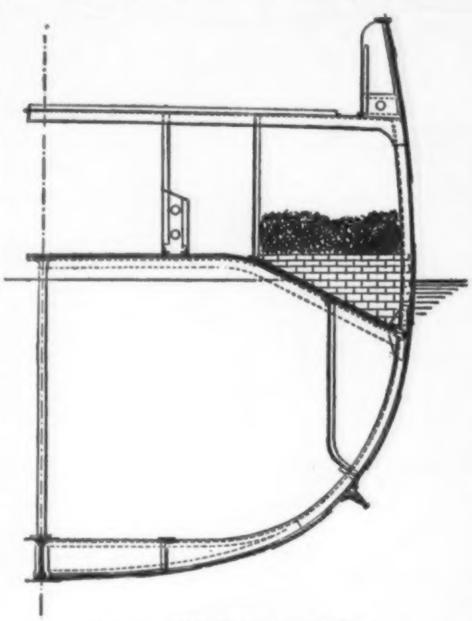


FIG. 1.—MIDSHIP SECTION.

of the belt is the same as the width measured vertically of the sloping side of the Piemonte's protective deck. The total thickness of the vertical armor attainable, supposing the plating behind the armor and an equivalent to the wood backing to be added as armor, is 10½ in. Giving the patent fuel a similar value in the case of the sloping armor arrangement of the Piemonte, *i. e.*, supposing its weight to be put into armor, the corresponding thickness of the sloping armor arrived at is 6 in.; this divided by the sine of the slope gives 14 in. as the thickness of the sloping armor, measured horizontally. Thus the advantage is with the sloping armor to the extent of 3½ in. But, besides this advantage in absolute thickness, vertical armor is much less effective in resisting projectiles than sloping armor of the same horizontal thickness. The patent fuel also has great advantages over an equivalent thickness of armor in resisting shell fire and especially shell charged with high explosives, as the resistance takes place over a greater distance, giving the shell time to explode, and the armor has only therefore to resist the broken pieces of the shell.

The arrangement with sloping armor has the disadvantage that light shell, which would be kept out by the vertical armor, will probably blow out some of the patent fuel, and do other damage to the ship's structure; but as the 6 in. quick firing gun can now penetrate 15 in. of wrought iron, this risk should, I think, be run for the sake of securing the additional protection afforded by the sloping armor. A shell from a 6 in. gun could be fired through the side with vertical armor, section Fig. 5, but the chances are very remote that it could be fired through the side of the Piemonte so as to penetrate the sloping armor, and especially if charged with high explosives. Moreover,

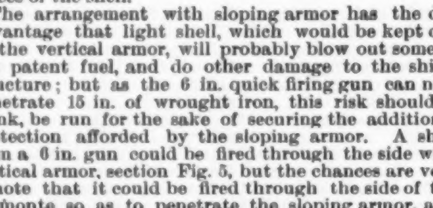


FIG. 5. FIG. 6.

against the disadvantage above referred to must be set the fact that the target presented by the comparatively thin horizontal deck, when the ship heels, is very much larger in the case of the ship with vertical armor than in the case of the ship with the sloping armor. The question of cost also is very much in favor of the sloping deck armor. Apart, therefore, from the advantage of being able to carry some 100 tons more coal in peace time, and of having this quantity in reserve to be used in an emergency in war time, the advantage appears clearly on the side of the sloping deck arrangement adopted in the Piemonte.

The relative advantages of vertical and sloping armor have been on more than one occasion lengthily discussed by this Institution, but the importance of the question must be my excuse for making the above comparison.

The machinery of the Piemonte has been constructed by Messrs. Humphrys, Tennant & Co., Deptford, and consists of two sets of vertical triple expansion engines. Each set has two low-pressure cylinders, and therefore acts on four cranks. The cylinders are of the following dimensions: high pressure, 36 inches; intermediate, 55 inches; low pressure, each 60 inches, and the stroke is 27 inches. Steam is generated in four double-ended boilers, adapted for a working pressure of 155 lb. Forced draught can be supplied by eight fans, but the stokeholds are arranged so that they can be worked with or without forced draught. Distilling apparatus of ample power has been provided for making fresh water for the boilers; and auxiliary condensers are also fitted in each engine room. An auxiliary boiler stands on the protective deck amidships, capable of supplying steam to any of the auxiliary engines throughout the ship.

The steam trials of the ship are only in course of being made. I had hoped that these would have been completed in time for me to have given curves of performance, but the continuous bad weather on the northeast coast during the last few weeks has prevented this. At a preliminary trial made on March 28th, some slight defects occurred in connection with the lubrication, which necessitated some adjustments. When these defects were overcome toward the close of the day, a series of runs were made on the measured mile, without the use of the fans, with open stokeholds, and with forced draught. There was very little wind on the occasion, so that much interest does not attach to the steaming without the use of the fans. Two runs, however, without the use of the fans showed that the ship could steam about 19½ knots under these circumstances. Four runs made with a moderate pressure of air in the stokeholds, never exceeding ¼ in. of water, gave a mean speed of 20·168 knots with an indicated horse-power of 7,700. With an air pressure of ½ in. of water, the limit fixed by the Admiralty for continuous steaming at sea, a speed of 20·3 knots could with ease be obtained with about 8,000 indicated horse-power. With closed stokeholds and forced draught a power of 11,600 horses was realized, but the trials under these conditions were not completed. The mean of two runs, however, when upward of 11,000 indicated horse power was realized, gave a speed of over 21 knots.

As I have stated, 21 knots was the speed aimed at in the design, and is also the speed which is guaranteed by my firm to the Italian government.

Whatever speed may ultimately be obtained in this vessel with forced draught, the fact that with natural draught, when the wind is favorable, or with a moderate pressure in the stokeholds, she can steam continuously in fair weather at from 20¼ to 20½ knots, has been fully established. This I regard as of very much greater importance than the high performance which will probably be attained with forced draught. Forced draught with high pressure in the stokeholds, and anything above 2 in. should, I think, be regarded as high, can only be reckoned upon for a spurt of three or four hours, and after such a spurt you will usually find that your boilers require some overhauling. At 20¼ knots the Admiralty displacement constant of the Piemonte is 190, which shows that very little work is uselessly wasted in the formation of waves. On Fig. 4 is shown the profiles of waves along the side of the vessel, at 20 and 21 knots speed, the full line indicating at 20 knots and the dotted line at 21 knots; and I have here some photographs, some of them taken from the foremost upper top, which show that the wave disturbance was remarkably small. So small was it when the ship was going upward of 21 knots, that her high speed could scarcely be realized. This was due partially to the entire absence of anything like excessive vibration. The vibration was measured by means of a seismometer, very ingeniously contrived by Mr. A. Mallock, and was shown never to have exceeded 0·12 of an inch, horizontally or vertically, at the extreme after end of the vessel, while the amplitude of the mean of the vibrations was less than half of this. With her full coal supply of 600 tons, the vessel will be enabled to steam the considerable distance of 1,950 knots at full speed with natural draught, and she will be able to maintain a cruising speed of 10 to 12 knots for 55 days, during which time she could cover a distance of about 13,500 knots. As will be seen from the profile, the after deadwood is cut away and a large balance rudder is provided, immediately in front of which also the deadwood is removed. These features will, I anticipate, give the vessel good maneuvering power, and from the trial already made there is no doubt that this has been secured.

We give an illustration from the *Engineer* of the Piemonte steaming at about 19 knots, taken from an instantaneous photograph.

[Continued from SUPPLEMENT, No. 699, page 11163.]

PLANT AND MATERIAL OF THE PANAMA CANAL.*

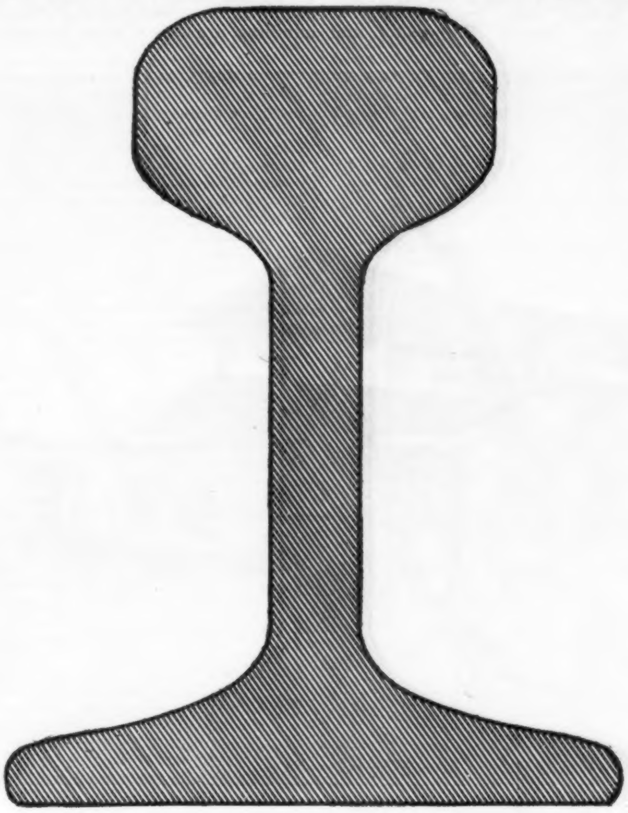
By WILLIAM PLUMB WILLIAMS, Jun. Am. Soc. C. E.

ROCK DRILLS.—A large consignment of the Ingersoll type of rock drills was sent down to the "Societe de Travaux Publiques" for use at Bas Obispo and at Emperador. These drills were in use only a few days, on account of insufficient number of skilled foremen to instruct the native labor in using them. Consequently the whole plant was abandoned. I did not see any machine drills in operation in crossing over the whole line, and the most modern plant which has accomplished such a wonderful work upon our New York aqueduct has been side-tracked at Panama for reasons dependent upon labor.

The French machine drills have proved a cumbersome appliance for all styles of work and uneven ground. A platform car, mounted on four wheels, supports a horizontal boiler of fifteen horse power. An upright frame supports four drills three feet apart, and these drills are raised and lowered by a ratchet and pinion attachment in the frame. A circular motion is communicated to each drill by a shaft from the main engine fitted with a beveled wheel. The drill is operated by a circular movement, being a borer rather than an up-and-down stroke. The contact of drill,

* A paper read before the American Society of Civil Engineers, July 2, 1888. From the *Transactions* of the Society.

holding it to its work, is regulated by hand of foreman of the machine. In order to work, a track of five feet gauge must be constructed upon the area subject to drilling and excavation, and the machine run on this railway at different points, set to work, and holes drilled to required depth. When a sufficient number of charges have been put in, the machine is run off the rock and the track removed and the number of holes fired by electricity. This cumbersome process is expensive on its face, as tracks must be constructed and removed, which can only be accomplished on level ground expeditiously, limiting the machine to level work, while an Ingersoll drill can be stationed on hilly and uneven ground, drill vertically, downward, or upward, or obliquely; no tracks are needed, and only men to transport the weight of the machine from place to place.



SECTION OF RAIL USED FOR CONSTRUCTION ON THE PANAMA CANAL.

FIG. 7.

A submarine rock drill has been successfully used on both ends of the line, and one at Fox River, at Colon, was built as follows: The hull of boat is 50 feet long by 20 feet broad, supplied with boilers for self-propulsion by screws and for communicating power for drills. Forward in the boat is an open square, 15 feet wide by 20 feet long, over which is a traveling frame supporting the drills. This frame has a fore-and-aft motion, running on tracks at each side of the boat. An extension shaft from the crank shaft by beveled gear wheels, transferring the power to top of frame, communicates the motion to drills, which are four in number, and are supplied with a screw end acting as a borer. A telescopic pipe, water tight, is lowered from the frame of the drill and is driven down into the bottom of channel, and the drills are then lowered and commence work inside of this water tight sleeve. The four drills make their holes, when the drill is withdrawn, and the charge put in and wired, the wires brought up out of the water and made fast to the deck. Then the frame is moved forward on its tracks a few feet and four more holes are drilled and loaded. The hull is controlled by fore-and-aft guys and side guys, thus limiting its work over a certain territory. When the area over which the open slot floats is charged, the hull is moved, and successive holes are drilled, when the boat withdraws a safe distance and the blast is made.

The coral rock at Panama and Colon has been disintegrated in this manner, and when broken in small pieces has been attacked by the dredges. I regard this means as quite successful in deep submarine work, and economical. The cost of an iron hull would be three to five thousand dollars with boiler and fittings of drills, and entire plant would not be over $2,000 more.

BLASTING.—Besides the holes of small diameter used in excavation of rock, larger shafts are resorted to, in cases where the material is of volcanic formation and porous, causing a charge to blow out in the cracks of the different strata.

A hole 1 meter square is excavated some ten meters in depth; at the bottom of this shaft two chambers are extended in either direction, 1 meter square and 2 meters each long. These chambers and the shaft are filled with barrels of powder and dynamite. At a distance of 5 meters below the surface of the ground cement is used as a filling, and after setting forms a solid mass of artificial stone to the surface of the ground. A number of these shafts are made and all fired at once. This immense explosive force shatters the surrounding mass, which may be easily attacked by the workmen with picks, loaded into buckets, and swung around and dumped into cars by cranes. In soft rock this has been the only successful means of working, but is costly on account of the large quantity of powder used in filling and loading the shafts.

The large works in hand are all accomplished at the present time by the use of churn drills, the ignorant workmen using drills from 6 to 15 feet long, of different diameters. They receive twenty-five to thirty cents per linear meter for holes of 6 to 8 feet in depth or under, and where the holes are over 8 feet in depth they receive from thirty to forty-five cents per linear meter, the quality of rock regulating the schedule of prices largely. These prices include the labor of loading and firing the holes, the cost of material to be furnished by the contractor. The cost of transportation in using rock drills, on account of weight of boilers and drills and frame, becomes an objectionable feature, and the general policy has been, in the absence of intelligent men, to pursue such simple means and appliances that when the ignorant force is left alone and without oversight they can accomplish satisfactory work, hence the substitution of the churn drill for our effective mechanical system.

STEEL RAILS. (See Rail Section, Fig. 7).—For construction purposes a rail weighing from 40 to 55 pounds per yard, and with base equal in width to the height, would be of sufficient strength, where the maximum weight at any one time is a French excavator of 36 tons, whose base is 30 feet; ties 2 feet from center to center. I find that one most costly mistake has been made on the Panama Canal by ordering for construction purposes over 120,000 tons of 70 pound steel rails, of such dimensions that the height largely exceeds the base. The Belgian locomotive weighs 30 tons, having three drivers and a rigid base of 13 feet, so that in curves of small radius or over 8 degrees the overturning movement is so great as to cause rails to spread, drawing the spikes. This has caused many derailments, and especially on construction tracks which are improperly ballasted the rail and tie must stand the whole strain. Then again on dumps or terraces where tracks must be frequently moved from side to side, it requires a larger force of men to do this work than if handling a 50 pound rail.

STEAM ENGINES.—The following firms are largely represented by their engines upon the Isthmus: Societe Cockerill; Societe Belgique; Societe Anonyme de Couillet Belgique; Rogers Locomotive Works; Baldwin type of Burnham, Parry & Williams. The Belgian locomotives are quite similar in construction, weighing 30 to 40 tons, supported by three drivers on each side, connected rigidly, the middle driver having no flange. Their capacity is hauling twenty-four loaded dump cars, weighing 10 tons each, up a three per cent. grade. They consume about three tons per day, and require a crew of three men and engineer. Wages of engineer, $4 to $5 per day; wages of men, $1.50 to $3 per day.

The foreign machinery is much heavier than the American, burns more coal, and gets much more easily out of order. The foremen and engineers on the line of canal prefer the Baldwin locomotive, manufactured

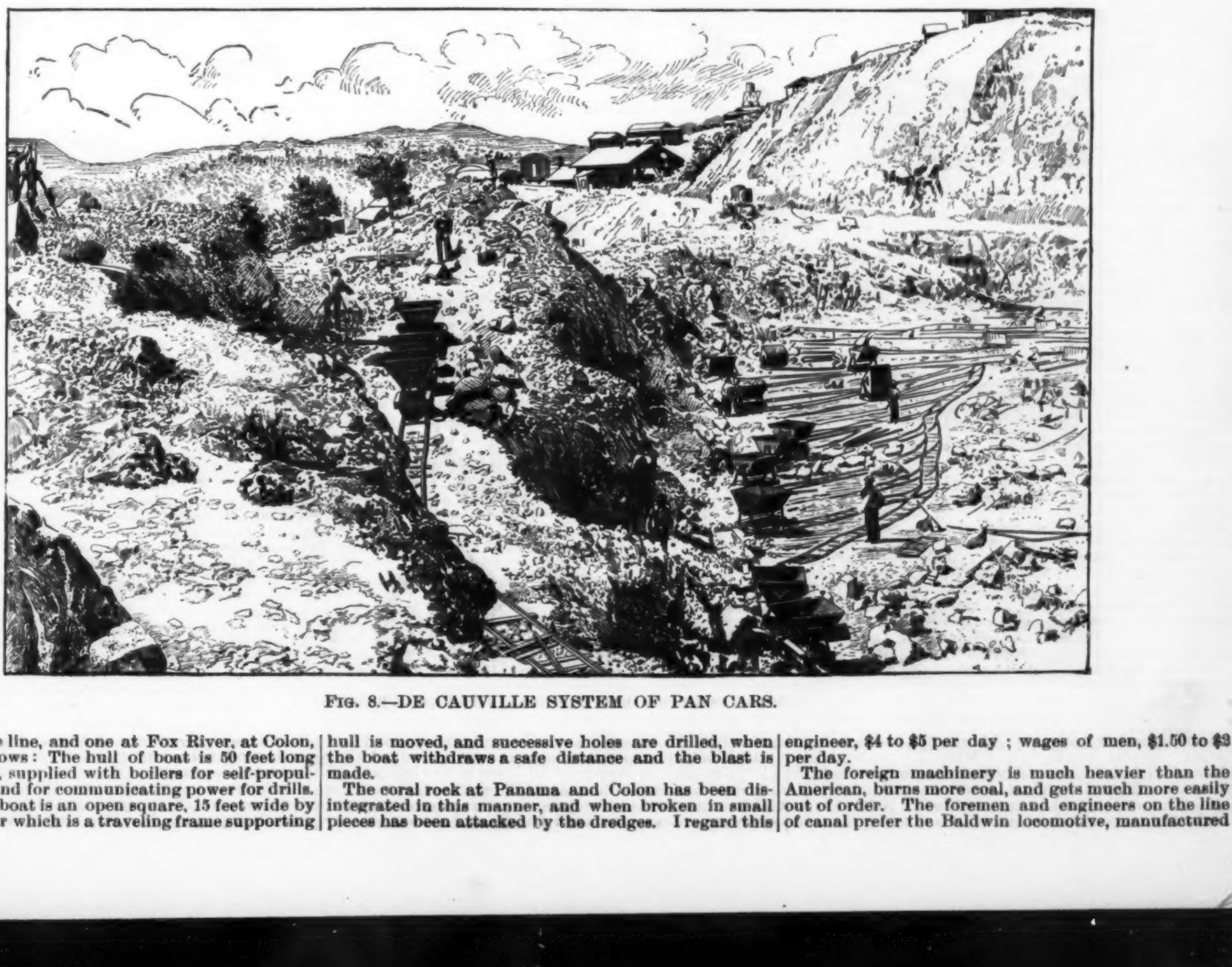


FIG. 8.—DE CAUVILLE SYSTEM OF PAN CARS.

by Burnham, Parry & Williams, for rapid work and easy control of parts. The Rogers engine is also in good form, and both American engines consume less coal than those of foreign manufacture. The cost has varied from $12,000 to $15,000, delivered at Colon.

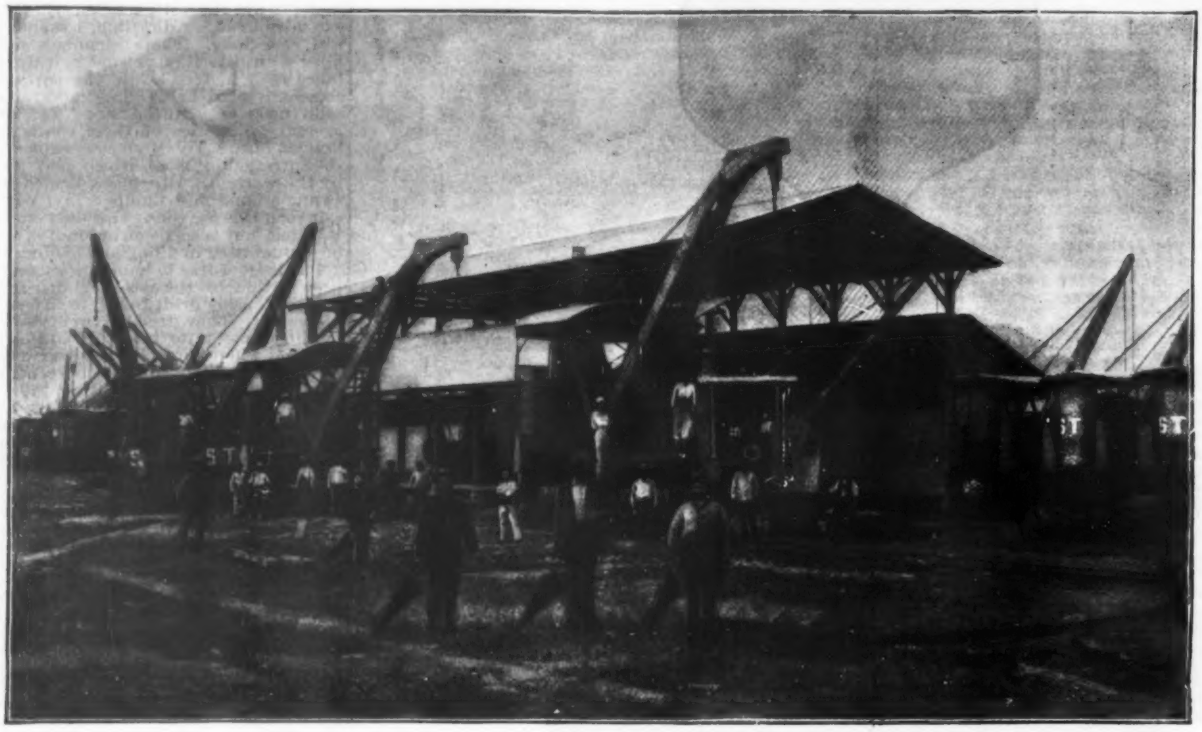


Fig. 9.—FRENCH AND ENGLISH CRANES.

De Cauville Cars (Fig. 8).—The De Cauville system of pan cars includes two styles, namely, the De Cauville and Baillard plant. The Baillard cars are of box shape, holding ½ cubic meter. The iron frame of truck is solid and holds the boxes of the wheels. The box is of iron, having a semicircular arc at each end, resting upon a grooved track, and in dumping the body of the car travels on the arc, throwing the box through an angle of 45 degrees. Their weight is 500 pounds, and cost $50 to $60 apiece. The gauge is 20 inches.

The De Cauville car is quite similar in the construction of truck, but the body of the car is shaped like a triangle, base uppermost, and supported by two lugs at each end, fitting into an upright frame made fast to truck. The center of gravity is in equilibrium when the car is full, and it may be easily dumped by throwing the body through an angle of 45 degrees.

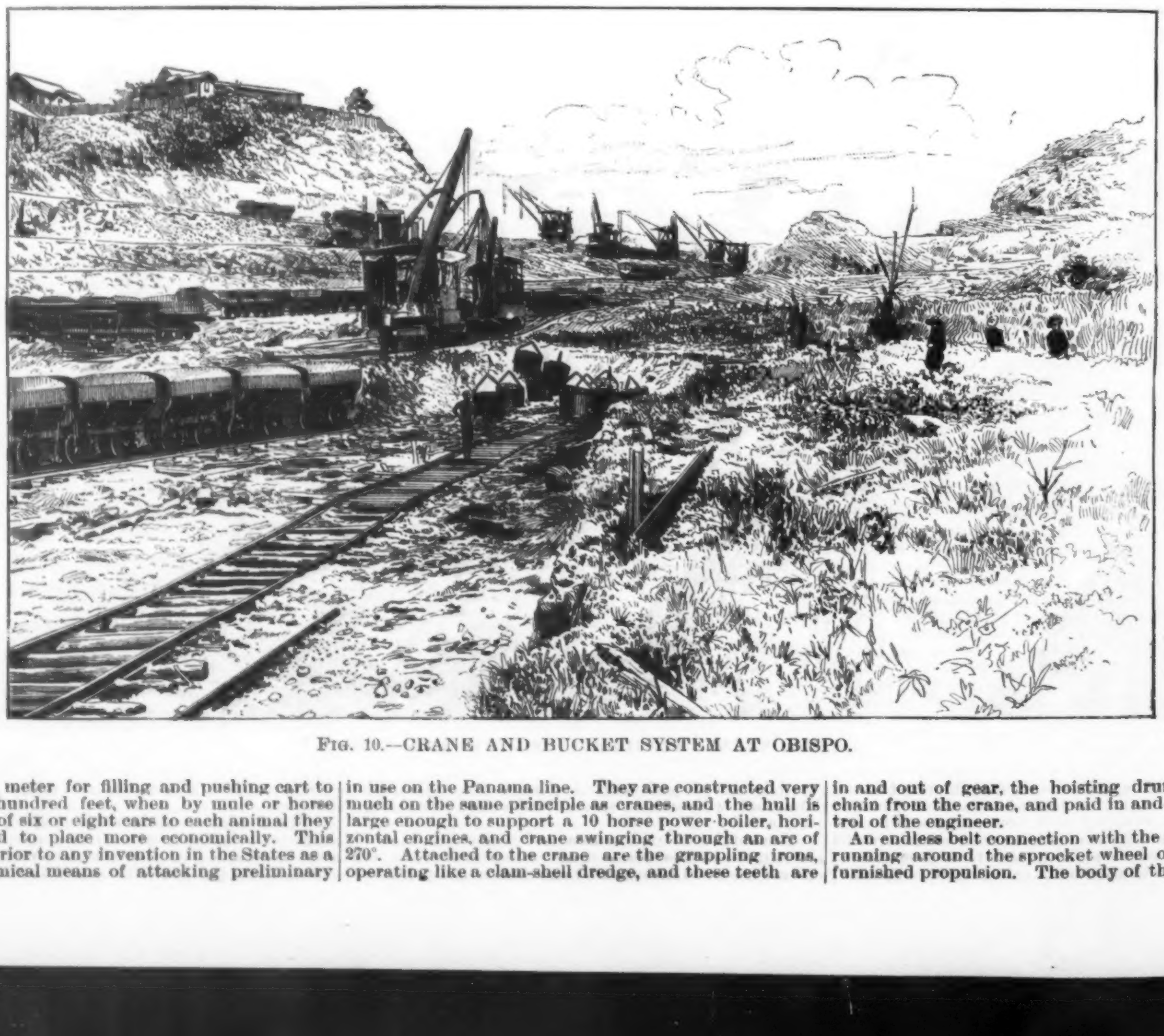


Fig. 10.—CRANE AND BUCKET SYSTEM AT OBISPO.

This size runs two and a half to three per cubic meter. The skeleton track is of 20 inch gauge and constructed in sections of 15 feet, the iron ties being made fast to the rails and easily transported in small space in large quantities. This plant is not in use with mules or horses on the Panama line, and I have seen numerous instances where they were used by the natives in executing task work, when they would receive thirty cents per cubic meter for filling and pushing cart to dump, several hundred feet, when by mule or horse labor and train of six or eight cars to each animal they could be hauled to place more economically. This plant is far superior to any invention in the States as a light and economical means of attacking preliminary work. In preparing cuts for excavators and in surface work where irregular territory is to be smoothed down for location of heavy construction tracks for steam excavators this plant is expeditious.

Broken Stone.—I found a French stone breaker at work at Pedro Miguel and at Buhio of larger and more massive construction than a similar American machine. The broken stone for the locks at Buhio, San Pablo, Bas Obispo, Emperador, and Paraiso is all task work and executed by hand, the men receiving $2 per cubic meter, and in many instances quantities of the stone broken during the last year has been of such quality that when exposed to the atmosphere it became disintegrated and crumbled. In nearly all cases of rock excavation for the locks at San Pablo, Buhio, Bas Obispo, Culebra and Paraiso solid stone is not met in the upper strata, and at the quarry of the Panama Railroad, at Buhio, is the only large quantity of stone suitable for masonry and concrete.

At several points along the line I noticed the broken stone had been whitewashed, and inquiring the reason, was told that the Jamaican laborers, during the night, would steal broken stone from one another's piles, which had been paid for at $2 per cubic meter by the contractor, the laborer turning in the stone to be paid for over again, and the contractor was obliged to adopt a whitewashing system to distinguish work paid for from that not accepted.

Submarine Rock Work.—In connection with the submarine rock drills may be mentioned the grapplers in use on the Panama line. They are constructed very much on the same principle as cranes, and the hull is large enough to support a 10 horse power boiler, horizontal engines, and crane swinging through an arc of 270°. Attached to the crane are the grappling irons, operating like a clam-shell dredge, and these teeth are lowered to the required depth, grappling the broken rock, which is hoisted to the surface, the crane swinging the load and dumping into a barge alongside. The hulls of these machines are constructed of iron in sections, the hull being 40x18x6 feet deep, and have been largely used in removing coral rock on the Colon side, which has been first broken up by drilling. These machines, on account of size of hull and easy means of handling, are able to move in shallow water and work in closer quarters than if cranes and grapplers were applied to each dredge as in the Hercules work, and in using them separately from the dredge much time is gained, as the dredge can keep on with her work, and independently of rock which may be afterward excavated.

Cranes. (Figs. 9, 10, and 11.)—Rock work in nearly all cases was executed by the use of steam hoisting cranes, which were used in large variety and of the following manufacture:

1st. J. Voreez Aine, Nantes, 1887. 2d. Stothert & Pitt, Bath, England. 3d. Applegate Bros., London, England.

The first named was of the "goose-neck" style of crane, which was supported on four wheels, car of 5 feet gauge, the whole crane weighing 10 tons and having a lifting power of 4 tons. These several machines were of the same weight, and the efficiency of work was dependent upon the manner of deriving power from the engine in hoisting the weight. In the first machine a friction clutch was used, being easily thrown in and out of gear, the hoisting drum receiving the chain from the crane, and paid in and out at the control of the engineer.

An endless belt connection with the crank shaft, and running around the sprocket wheel on the car axle, furnished propulsion. The body of the crane rests on

a central axis, allowing it to swing through a circle. The axis of the crane has a large gear wheel, into which fits a smaller gear wheel, receiving power from the crank shaft. The mode of action is as follows: The rock, when broken up, is loaded by hand into wrought iron cylindrical buckets, some holding ½ cubic meter and large sizes holding 1 cubic meter, the task men receiving twenty to thirty-five cents per cubic meter for this work.

The buckets are made fast to the end of the chain, and the engineer of the crane hoists them up and swings them around on to cars, where they are dumped. The capacity of work has varied largely, but at San Pablo and Bas Obispo they average nine cars a day of 6 cubic meters each; but this is much too small, as when properly supplied with buckets they might accomplish at least 100 cubic meters work. A limited number of men working in a small area could fill only as many buckets as space would allow; and meanwhile the crane might travel up or down the track to different squads of men, hoisting and emptying the buckets as fast as filled, the dump cars standing on the second track, behind the track of crane, and in this manner would accomplish a much greater amount of work.

In the rainy season, when construction tracks are difficult to keep up, this crane is especially useful, as, on account of its light weight and low center of gravity, it is not as easily upset as excavators, and it has been frequently used in earth work. The working force necessary is one engineer to each crane, paid $3 to $5 per day, and one fireman to three cranes, receiving $2 per day; one carman and one bucketman to each crane, $1.50 each per day. The coal used per day averages ½ ton.

In machines Nos. 2 and 3 the power is derived from a gear wheel on the crank shaft connecting with the gear wheel of the hoisting drum. The boilers are horizontal and the center of gravity is thrown as far to rear of crane as possible by loading the platform on back with

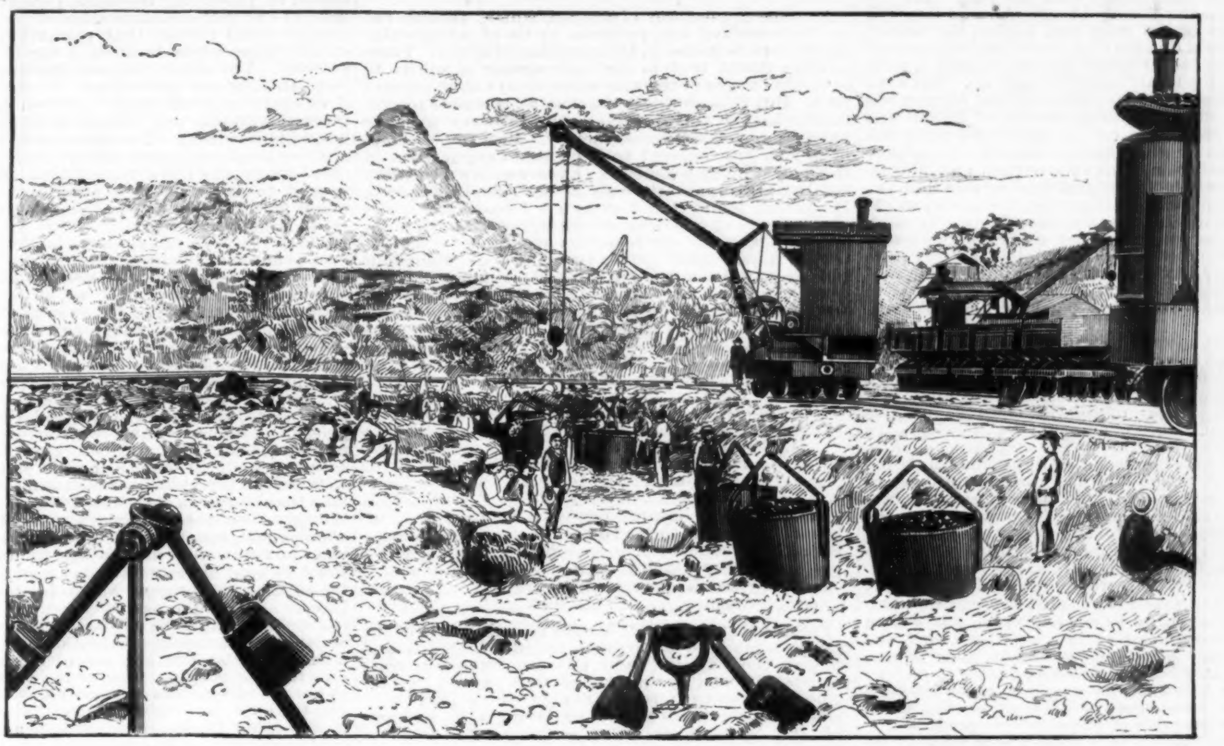


FIG. 11.—ROCK CUT SHOWING SYSTEM OF CHURN DRILLS AND CRANE BUCKETS.

rails as heavy ballast. When ready for work the frames are in some cases "jacked up," giving a wider support for a working base, as the arms are 8 feet centers and jacks 7 feet apart. Of the five varieties in use, No. 1 has executed good work, and the less liability of parts to get out of order is an important element. These machines are built in sections and transported and put up on the scene of work. Cost, F. O. B., about $5,000.

PONTON BIQUES.—Large floating cranes are used at Colon and Panama in transshipping a heavy cargo from deeply laden vessels of large draught, on account of their inability to run alongside of the canal wharves. The largest size has a lifting capacity of 40,000 pounds. The hull is 60x30 feet and of 10 feet draught, supporting a derrick on the forward end of 75 feet height and a reach over sides of hull of 30 feet. This crane has been used in lifting the heavy sections of dredges from the holds of ships, and swinging them around and loading them on to flat cars of the Panama Railroad for shipment upon the line.

This crane has the power of a stationary crane, and may be moved from place to place when necessary, by a system of guys, which are reeled up on hoisting drums on board of the ponton. The crew necessary is, one engineer, one fireman, one man on the tower, two men in charge of guys, engineer in charge of hoisting engine, and engineer in charge of "swinging derrick." The use is limited at Colon to unloading vessels, and it is seldom at work more than half of the time. On account of gaining the proper stability, it must have an immense hull to support the weight. The entire plant is expensive in the extreme, and if a proper wharf had been first constructed, dredged out its entire length, and a track laid to allow the passage of freight cars, a permanent crane might have been erected at half the cost and less expense of operating.

MARINE CRANES.—I noticed a number of self-propelling steam cranes at Colon, having a capacity of hull to hold 500 tons of freight. These cranes went alongside the steamers, made fast, and discharged the cargo of the steamers, receiving it with the chain and crane, and swinging it around to the hull of crane until filled, when another crane would come alongside and repeat the operation. These cranes would then steam up the line and unload at the different shops or storehouses. In all cases they were used in unloading the heavy parts of machinery, such as boilers of dredges, excavators, cranes, locomotives, and dump cars. Their capacity was 10 tons, and usually two cranes were mounted on each hull. These floating cranes of this size I regard as indispensable, as at some time all available wharf room might be in use and a steamer arriving at this time would suffer demurrage in not being able to discharge her cargo, while a floating crane might make fast alongside when the steamer was anchored in the harbor, and discharge into the hull of crane, or upon scows alongside. Many steamers are provided with cranes or use tackles and yard arms, but it would be slow work as compared to a distinct plant for the purpose.

(To be continued.)

SOME INDUSTRIAL APPLICATIONS OF OXYGEN.*

By L. T. THORNE, Ph.D.

Now that the work carried out during the last few years, under the auspices of Brin's Oxygen Company, has resulted in the solution of the long mooted problem of the preparation of oxygen on the large scale at a price which should bring it within the range of industrial applications, it may be of interest to call attention, very briefly, to one or two such applications which have, up to the present, been investigated.

But before entering on the consideration of these applications it will probably be well to refer, in a few words, to the present position of oxygen production. For though Boussingault's classical researches pointed undoubtedly to the atmosphere as the source for oxygen, and to barium oxide as the medium for its extraction, the practical difficulties of the process—one of the chief among which was the gradual diminution of the absorptive power of the oxide for oxygen—have hitherto prevented its being practically carried out.

The last named difficulty having been overcome by taking special precautions to obtain the baryta employed in a suitable physical condition, and to suitably purify the air from carbonic anhydride and moisture, the further difficulties of economical heating and of converting a small laboratory experiment into a commercially practical process had to be grappled with.

As the present paper does not purport to be on the production of oxygen, but on its applications, it is unnecessary to follow the development of the process in all its details. Suffice it to say the difficulties have been so far overcome that, including all costs, the production of oxygen by this process will certainly not exceed 7s. 6d. per 1,000 cubic feet in London. In the manufacturing districts, where coal and labor are much less than in London, the cost will be reduced to about 5s., and in gas works and other places, where special facilities as to fuel, power, etc., exist, the cost will be still further reduced.

The furnaces now in use are of several kinds, the retorts being placed in some horizontally, in others vertically. One recent modification, that may in many circumstances prove very advantageous, is the adoption of a constant temperature for the furnace and retorts.

The temperature employed lies between the temperature most suitable for oxidation and that most fitted for deoxidation, the air being pumped in during oxidation under a pressure of from 15 to 20 lb. on the square inch, and the oxygen drawn off by means of a vacuum. Under these circumstances neither the oxidation nor deoxidation of the baryta is so complete as when varying temperatures are employed, and the yield of oxygen per operation is in consequence much smaller. Still the change of pressure is sufficient to determine a certain variation in the state of oxidation of the baryta, and this is aided to some extent by the cooling effect, during oxidation, on the baryta of the cold air pumped in. And though the yield of oxygen per operation is small—about 0·1 ft. per lb. of baryta used, against about 0·7 where the temperature is changed—the number of operations per day is so much increased, and the manipulation so much simplified, that this form of furnace will, under most circumstances, be more advantageous than the older form.

Turning now to the applications of oxygen, I would take the opportunity to apologize for bringing this subject before the Society in its present unfinished state. When at the beginning of the session I undertook to read a paper before you, I fully hoped that the chemical or theoretical side of the questions to be treated of would, ere this, have been worked out. Owing to press of work, however, the necessary laboratory experiments have not yet been completed. Nevertheless, I thought it best to lay before you the facts already ascertained, and trust at a future time to be allowed to return to the subject when further research has given more definite insight into the *rationale* of the various processes.

THE USE OF OXYGEN IN BLEACHING.

It is, of course, well known that in the bleaching of natural coloring matters by chlorous bleaching agents, the true bleaching agent is, in almost all cases, oxygen. But all attempts to employ free oxygen in the place of chlorine or chlorine compounds have hitherto proved unavailing, except perhaps in the open bleach field, where the action of the oxygen is aided by sunlight. The opinion has therefore grown up that before oxygen can become an active bleaching agent, it is necessary for it to be in a nascent state, or at least in its active form of ozone. Experiments recently made have shown, however, that this opinion is only justified up to a certain point; for though all attempts to bleach by the action of free oxygen alone—whether at high or low temperature, or under normal or increased pressure—were unsuccessful, it was found that when used in conjunction with chlorine or bleaching powder, oxygen possesses a most decided bleaching power. The experiments were made with paper pulps—wood, straw, esparto, and jute or gunny—and also with raw jute, jute yarn, and cloth, and cotton cloth. The results were similar in all cases, but since, as yet, the experiments on yarns and cloths have been confined to the laboratory, the remarks in the present paper will be mainly confined to the bleaching of paper pulps, with which experiments have been carried out on a practical scale.

When a stream of oxygen was passed into a mixture of paper pulp and solution of bleaching powder, it was noticed that the decoloration of the pulp proceeded much more rapidly than was the case when no oxygen was used. At first it was thought that this might be due to the mechanical stirring effect of the current of oxygen. A stream of nitrogen was therefore substituted for the oxygen, but the result was a retardation of the bleaching. A current of air was then tried, the effect being that the rate of bleaching was almost exactly the same as when bleaching powder solution was alone used. When equal volumes and strengths of solution and weights of pulp were used, the residual liquid from the oxygen experiment always contained, after the bleaching was complete, more available chlorine than either of the others. It thus became clear that oxygen produced a beneficial, nitrogen a detrimental effect, while the apparent inaction of the air current was probably due to the effects of the oxygen and nitrogen neutralizing one another.

Experiments were now undertaken in a closed churn, and it was found that when using about 28 lb. dry pulp, mixed with a solution of bleaching powder, from six to eight feet of oxygen might be slowly passed into the churn without any increase of internal pressure being shown. When nitrogen was passed in, the pressure began to rise immediately, and when the excess of nitrogen was allowed to escape, it was found to be strongly charged with chlorine. When air was used the pressure rose steadily, but more slowly than with nitrogen, and the excess of gas was found to contain but

* A paper lately read before the London section of the Society of Chemical Industry. From the *Journal* of the Society.

little oxygen, but to be strongly charged with chlorine. There could thus be no doubt that the oxygen was actually used up and helped to effect the bleaching, while the nitrogen was not only without bleaching effect, but when escaping from the liquid carried away with it part of the chlorine which is constantly being set free in a solution of bleaching powder. And even with oxygen the absorption was limited, and if too much was passed in or it was admitted too rapidly, pressure rose at once, and the excess was not only useless, but detrimental.

Further experiments showed that not only did a stream of oxygen accelerate the bleaching, but that it very considerably reduced the quantity of bleaching powder necessary. In a large number of experiments the saving of bleach which was effected ranged from 40 to 50 per cent., the saving being greater the finer the state of division of the oxygen on entering the pulp, and the more intimately it was brought in contact therewith.

But it is one thing to make a laboratory experiment, another to carry the experiment into practice, and the above detailed results had yet to stand the test of practical working. Arrangements were therefore made to test the process on a large scale at a paper mill. Two large open potchers, each capable of carrying nearly a ton of straw or esparto, were fitted with a finely perforated tube running across the potcher just in front of the beater, and the whole of the pulp bleached in these two potchers during five days was treated, the total amount being over 50 tons of esparto, straw, etc. The conditions of the trial were disadvantageous to the process, since the potchers being open with only about 20 inches head of water, it was difficult to bring the oxygen intimately into contact with the grass and to prevent a large quantity of it escaping. In order to do this as far as possible, the above mentioned position was chosen for the oxygen pipe, as the revolving beating cylinder then prevented the oxygen rising straight to the surface of the liquid, carried it forward, and did much to bring it into contact with the pulp. But, on the other hand, the strong bleach was run into the potcher on top of the pulp, etc., behind the beater, and it was about a quarter of an hour before it became well incorporated and reached the oxygen pipe, a large part having in the meantime been used up. But even under these conditions the effect of the oxygen was very marked, and the average saving of bleach was about 30 per cent., at a cost of about 200 cubic feet oxygen per ton of raw material treated. In a more permanent installation, where the oxygen and bleaching solution would be introduced side by side and the distribution of the oxygen improved, the saving would undoubtedly be much larger and would probably reach that obtained in the laboratory experiments already detailed. This process may be applied at very little cost to almost all existing paper bleaching plant, and besides the saving of bleach, decreases the damage to the fiber and thus produces a paper of increased tensile strength.

With chlorine, oxygen acts in the same way. Whether used for gas bleaching, or whether the mixed gases are led into water in which paper pulp is suspended, a considerable quantity of oxygen is absorbed, and a saving of about 50 per cent. of chlorine effected. To give a single example, a glass chamber of 4·4 liters capacity was lightly filled with 200 grms. dry jute, slightly moistened, and was then made air tight, and connected with a retort in which chlorine was afterward generated. Oxygen was passed into the chlorine mixture (manganese dioxide and hydrochloric acid), and the mixed gases then led into the closed chamber: 7·6 liters of oxygen and 3·8 liters of chlorine were thus passed slowly in, but the pressure in the vessel only increased to about 20 mm. water. In the experiments with chlorine and oxygen it was always found that better results were obtained when the oxygen was passed into the chlorine-generating mixture than when the gases were simply mixed before reaching, or in, the bleaching chamber. I am, however, unable at present to say whether this was due simply to more intimate mixture of the two gases, or whether possibly small quantities of some oxide of chlorine were produced.

Sufficient experiments have not yet been made to enable me to say with any certainty what is the chemical explanation of the above phenomena. It is conceivable that the oxygen in some way regenerates the chlorine or bleaching powder at the moment of their conversion into hydrochloric acid or calcium chloride, or, on the other hand, that a part of the oxygen becomes converted, in the presence of the nascent chlorine, into ozone. It is more probable, however, that the bleaching of the natural coloring matters present in fibrous materials does not take place at one bound, but by stages, some of the intermediate products being of an aldehydic or unstable character, and oxidizable by free oxygen. Under ordinary circumstances, no free oxygen being present, the end as well as the initial oxidation must be effected by nascent oxygen supplied through the medium of the chlorine. But if a plentiful supply of oxygen is present, less nascent oxygen, and consequently less chlorous bleaching agent, is required. One fact that tends, I think, to confirm this explanation is that when a current of oxygen is passed through a solution of bleaching powder undergoing titration with arsenious acid, the amount of arsenious acid is not increased. Were the increased bleaching effects described above due to a formation of ozone or a regeneration of oxychlorine compounds, an increased quantity of arsenious acid should be oxidized under the conditions just mentioned.

USE OF OXYGEN IN THE PURIFICATION OF GAS.

As Mr. W. A. Valon recently (June, 1888) read a paper on this subject at the annual meetings of the Gas Institute, and this paper, with the discussion thereon, has already appeared in the *Transactions* of the Institute (1888, pp. 71-98), it will be unnecessary for me to go into the question in detail. It is, however, of such importance, that I may be permitted to give a brief summary of the principal results.

In gas works where oxide of iron is employed for the removal of the sulphur from the gas, the spent oxide is often revivified by being exposed for some time to the air, and this may be repeated ten or a dozen times before the oxide is finally spent. But in order to save the handling of the oxide thus made necessary, a small percentage of air is often added to the gas before it enters the oxide purifiers, and in this way the revivification is made continuous, till the oxide is finally completely spent. But when either of these plans is adopted, the purified gas is generally found to have lost somewhat in illuminating effect, due probably to the nitrogen introduced in the added air. Mr. Valon made a series of experiments to ascertain whether any material advantage would accrue by the substitution of a corresponding amount of pure oxygen for air. He found that not only did the loss of luminosity give place to a slight increase, and the revivification of the oxide proceed more regularly, but that the use of the oxide might be abandoned altogether. For when oxygen was employed in this way, the lime purifiers alone were found to efficiently remove the sulphur compounds, the issuing gas containing only six to eight grains of sulphur per 100 cubic feet of gas. The proportion of oxygen found to give the best results was 0·10 per cent. of the volume of the gas for every 100 grains of sulphur per 100 cubic feet of crude gas. Under these conditions the sulphur remained fixed in the lime (partly as free sulphur), and did not move forward when the lime became saturated with carbonic acid—as is the case where air is employed—and the life of the lime was nearly doubled. The lime lasts much longer than hitherto, owing to the more complete revivification of the lime, and when spent it has not the noxious smell of "blue billy," but forms an almost odorless and dry substance. The purifying space and plant is reduced by more than one-half, and the labor in proportion.

The chemical explanation of these results must be left for the present unknown, but of the actual facts there is no doubt. The experiments were made at the Westgate-on-Sea Gas Works, between September, 1887, and May, 1888, and during that time the whole output of gas was treated by the oxygen method. Permanent oxygen plant has now been put down at the Ramsgate Corporation Gas Works, and the process will shortly be at work, when those interested in gas making will be able to examine it personally.

MATURING OF SPIRITS.

Another application of oxygen, which, though not yet fully worked out, promises to be of considerable importance, is its use in the maturing of spirits. There is little doubt that in the early ageing of spirits in cask, the oxygen of the atmosphere plays an important part. But though this is the case, all attempts to artificially hasten this process seem hitherto to have proved more or less unsatisfactory. But the two applications just referred to show that oxygen when in the pure state may sometimes answer where air utterly fails, and this is also the case in the ageing of spirits. It has been found that if oxygen is forced into spirits at a pressure of one or more atmospheres and left for ten days or so, the spirits become mellowed to the extent of about three to five years' ageing. Numerous samples have been thus treated and submitted to experts, with the almost invariable result as stated. Determinations of the fusel oil in some of these samples have been made, of which the following three pairs are examples:

		Fusel Oil.
I.	Whisky before treatment	0·2 grms. per liter.
	Whisky after treatment	0·06 " "
II.	Whisky before treatment	0·3 " "
	Whisky after treatment	0·02 " "
III.	Whisky (quite new Scotch) before treatment	1·63 " "
	Whisky (quite new Scotch) after treatment	0·42 " "

From these numbers* it is clear that the effect of the oxygen is really to mature and improve the spirit and convert the harmful fusel oil into innocuous compounds. It may be mentioned that oxygen has for some time past been used in France for this purpose.

Some wines appear also to be matured by this process, but they are also often acidified by it, and it is doubtful whether it will be applicable to wines with advantage.

USE OF OXYGEN FOR OBTAINING HIGH TEMPERATURES.

As the able paper delivered by Mr. Thos. Fletcher on this subject to the Liverpool Section of our Society has already appeared in our *Journal*, it is unnecessary for me to do more than refer to it. I would, however, take this opportunity of calling the attention of chemists who have not yet used it to the convenience of compressed oxygen as now obtainable in steel cylinders, for laboratory use. There is also little doubt that at the prices mentioned at the commencement of this paper, oxygen will be available even in some metallurgical operations where very high and readily controlled temperatures are required.

Several other industrial applications of oxygen are now under investigation, and I hope ere long to have the honor of bringing these before the notice of the Society.

DISCUSSION.

The chairman said that he was sure all the members would agree with him in thanking Dr. Thorne for an especially interesting paper. It was surprising that oxygen had been so completely shut out from all industrial uses until recently. The most familiar of all chemical substances, the first thing to a knowledge of the use of which every beginner in chemistry was introduced, had hitherto been so scarce and valuable that its industrial employment was impossible. Excepting a very limited use in oxyhydrogen furnaces, it might be said that the industrial application of oxygen in chemistry was unknown. Messrs. Brin's process had created the possibility of the industrial use of oxygen, and was in itself a most interesting object of study. The first effects of the introduction of this process were a repetition of what had been so often seen before: a discovery was made so simple and so admirably fitted for its purpose that everybody immediately concluded that the whole question was solved. Then the practical difficulty of applying the process came to the fore. Perhaps there was nothing more certain with respect to industrial processes than that nothing, however perfectly simple in the laboratory, ever worked well at first on a practical scale. It was not merely beautiful laboratory experiments that were wanted in applied chemistry, but the more complex results of great engineering and manufacturing experience allied to that purely theoretical chemistry which we are apt to think all sufficient. It was most interesting to see how the difficulties besetting the process had been overcome, and results obtained indicating that the various applications of oxygen had a great future. The whole question of bleaching was one of great interest and importance, but he would not venture to dogmatize on it. Undoubtedly oxygen had for centuries past done a large amount of bleaching; in fact, until the present generation or thereabout, all bleaching had been done by it. At any rate, without going deeply into theories, one might assume that oxygen had *some* bleaching power. How that power was exercised was a difficult and interesting question. He felt strongly, however, that Dr. Thorne was right in his view that chlorine was not the true bleaching agent. It was probable that it acted simply as—it was difficult to choose expressions which did not bring one on to a debatable ground, but perhaps he might use a safe, if incomprehensible, expression, and say that it acted in a catalytic manner. At any rate it seemed clear that the joint presence of ordinary oxygen and oxygen combined with chlorine did somehow produce the effects characteristic of ozone.

If this process could avert the destructive effects produced by chlorine in paper pulp, it would be a vast consideration to all who had respect for the permanence of documents; and if it could be carried still further and avoid the extreme use of chlorine in our clothes, that would be an improvement which would add materially to the happiness of the community. It must be confessed that modern science had not succeeded in producing the same permanence which the linen of our grandmothers showed; and if the oxygen process could restore that permanence, everybody—except those whose business it was to spin—would be grateful. The other proposed applications of oxygen were striking and interesting. In the case of spirits, if we could be saved what had been called torchlight processions down our throats, that alone would be a great improvement. The ageing of spirits was another of those simple processes difficult to analyze and work out. Every one knew that it took place, but no one seemed to know how. It would certainly be an economic and valuable application of oxygen if the interest of large sums of money which at present lay idle while spirits were ageing could be thereby saved. He would not go through all the possible applications of oxygen, some of which were well recognized at present, while others belonged only to the future, but would call upon those having knowledge of the subject—especially those learned in the purification of coal gas—to give the meeting the benefit of their experience.

Mr. S. H. Johnson said that with respect to the bleaching properties of oxygen, he would like to ask Dr. Thorne whether he had compared the cost of the oxygen used with that of the chlorine which it displaced. A thousand cubic feet of oxygen would weigh, roughly, about 14 lb., and its cost would be 7*s*., or about 6*d*. per pound. In comparing the cost of that oxygen with that of the chlorine which it displaced, one must take the chlorine in the form of bleaching powder. He thought that the two values would be found to be about equal, and thus there would be no saving. It was, however, very interesting to find that oxygen could be used directly in such a way, and it was to be hoped that the process would be cheapened in the future. He would like to hear Dr. Thorne's opinion of the saving to be effected by using oxygen instead of oxide of iron for the purification of gas. He had had a long experience of the use of oxide of iron and of lime for that purpose. One of the principal objections to the use of lime was the enormous expense of handling the lime; but this expense was saved in the case of iron oxide by the same oxide being used over and over again, and he had no doubt whatever that oxide of iron was by far the cheaper agent for purifying gas from sulphide of hydrogen.

Mr. B. E. R. Newlands asked how it was possible to correctly estimate such a small quantity of fusel oil in spirit as that mentioned as existing after treatment by oxygen. He had failed to get accurate results by the book methods, and therefore when he inquired into the matter during a recent visit to Paris he was somewhat gratified to find that one of the most eminent chemists in the alcohol industry confessed himself equally at a loss to estimate such minute proportions of fusel oil. In fact, fusel oil was a very complex body. It was essentially a mixture left in the still after the alcohol was distilled off at a certain temperature, and the oil at one manufactory might differ considerably from that at another. Therefore a process that would determine it correctly in one works would perhaps fail to determine it at another.

Mr. E. J. Bevan was glad to find that Dr. Thorne regarded oxygen as the chief agent concerned in bleaching, rather than chlorine. At the same time he would like to know how Dr. Thorne explained the action of chlorine on jute in the experiment he had described, in which he had passed chlorine gas into a glass cylinder containing jute. It was well known that jute was not bleached at all under such conditions. The chlorine was absorbed by the jute, forming a chlorine compound of definite composition, and thus accounting for the non-increase of pressure mentioned by Dr. Thorne. He would like to know, too, whether the bleaching effected by means of oxygen and bleaching powder had been found to be permanent. That was a matter of great importance to paper makers. It was possible to produce what might be called a white wash as contrasted with a distinct bleach. In some cases bleaching could be effected very rapidly, and a good white apparently obtained; but after some time the pulp rapidly deteriorated and went back to the original color. But after all, the most important point for a papermaker's consideration was the relative cost. He would like to hear Dr. Thorne's opinion on that, and also whether he had estimated the loss in weight which occurred with pulps treated by the two different processes, *i. e.*, by bleaching powder alone and by bleaching powder in conjunction with oxygen. He would also be glad to know whether Dr. Thorne had deter-

* It should be noted that these numbers are given rather for their relative than their absolute value. In these determinations the numbers to be compared are from the *same* spirit before and after treatment, and therefore are in a great measure free from the objections raised against ordinary fusel oil determinations. The alcohol of the spirit was carefully fractionated off by the help of a Le Bel Henninger fractionating tube (four bulb), and the aqueous residue treated by Marquardt's method.

mined what action, if any, was produced by oxygen alone, without the use of any bleaching powder.

Dr. C. R. Alder Wright asked whether the "blue billy" shown by Dr. Thorne contained free sulphur or calcium sulphide, or whether the sulphur compounds in it had been oxidized to sulphate; and whether the action of the oxygen had been traced by the analytical examination of the product. There was another application of oxygen which had been brought forward some time ago, which Dr Thorne had not mentioned: that was its use for purifying water by being dissolved therein. It was a curious fact that a watery solution of oxygen under several atmospheres pressure in a siphon, when discharged into a tumbler, was just as tasteless as boiled water.

Though "fizzing" vigorously, it tasted as flat as ditch water. He had gathered from Mr. Jackson some time ago that there was a prospect of oxygen being used for the purification of water containing organic matter, but had not yet heard of any experiments to that end. Mr. Jackson had, however, kindly sent him for home consumption sundry samples of plain aerated water and of lemonade aerated with oxygen. He had noticed that the oxygen had by no means completely oxidized the citric or tartaric acid of the lemonade nor the essential oil and sugar contained therein, and it therefore occurred to him that there might be certain constituents of ordinary water which it would equally fail to oxidize.

Mr C. T. Kingzett asked whether Dr. Thorne had made any estimation of the comparative cost of oxygen by the Brin process and in the form of peroxide of hydrogen in the application of the two substances to such bleaching processes as the oxidation of paper pulp and fusel oil. And further, whether the oxygen employed to purify gas prevented the formation of that magnetic oxide of iron which was the bugbear of the process. If one could really prevent the formation of magnetic oxide, there was no reason why the ferric oxide should not be employed *ad infinitum*.

Mr. A. Wingham said he understood that the sulphur in the "blue billy," shown by Dr. Thorne, was in the state of free sulphur. If that was so, it seemed very remarkable that one should introduce oxygen into the gas and get a reduction. The probable explanation seemed to him to be that the oxygen being introduced into the gas burnt by preference a certain amount of sulphureted hydrogen into sulphurous acid, which, reacting on the unburnt sulphureted hydrogen, gave free sulphur; the lime acting simply as a mechanical filter. If that was so, the objection to the cost of lime would be overcome, as coke could be used. With respect to the application of oxygen to bleaching, he would like to ask Dr. Thorne to what extent he could replace chlorine by oxygen; and, if the oxygen had a catalytic action, whether he had experimented as to the amount of chlorine necessary to enable oxygen to bleach, whether a trace only would be sufficient. In this connection he would draw attention to the great desire that existed at the present time for a really pure paper for artistic purposes. He had had complaints recently from several artists that the paper supplied to them rapidly destroyed the colors put on them, especially the vegetable colors. There would certainly be a demand for any process which should overcome this fault.

Mr. H. Sharp said that he was glad that, though a member of the Society, it did not fall to his lot to answer the various technical questions raised on the subject of Dr. Thorne's paper. One gentleman had inquired as to the cost of bleaching by oxygen as compared with peroxide of hydrogen. Dr. Thorne would probably answer that question; but in the meantime he might say that they had not attempted to compete with peroxide of hydrogen—or rather that hydrogen peroxide had not, he thought, attempted to compete with their oxygen. The former would, he believed, be much more expensive. His object in rising, however, was, as chairman of Brin's Oxygen Company, to emphasize an invitation which had already been sent to the council. He trusted that the council would accept that invitation, and that the society, on its annual meeting this year in London, would pay a visit to the works and see the industrial production of oxygen going on. It was unfortunately beyond their power to show members all the applications of oxygen; but he would assure them of a most hearty welcome. He would now leave the answering of the questions to Dr. Thorne.

Dr. Thorne, in replying, said: In the first place as to the question asked by Mr. Johnson, and repeated by other gentlemen, concerning the relative cost of oxygen and bleaching powder—if Mr. Johnson reflects for a moment, he will recognize that he has made a slip in his calculation. A thousand cubic feet of oxygen weigh about 84 lb., and not 14 lb. as he mentioned—the volume of one pound of oxygen at the ordinary temperature of 60° Fah. being about 11·8 ft. This of course will reduce the cost of the oxygen from the sixpence suggested by Mr. Johnson down to about a penny per pound.

I may say, however, that we have studied the question of the cost of bleaching, and it would be within the mark to say that the ordinary cost of bleaching paper pulp is about 15*s.* to 18*s.* per ton of raw material. In some cases it is a little higher, in others a trifle lower. As already mentioned in my paper, in experiments on the large scale a saving was effected of about 30 per cent. of this cost, which is equivalent to between 5*s.* and 6*s.* That saving has been effected at the cost of from 180 to 250 cubic feet—or an average of about 200 cubic feet—of oxygen to the ton of raw material. This quantity of oxygen costs in London about 1*s.* 6*d.*, and we, therefore, have to deduct that sum from the saving of 5*s.* or 6*s.*

In the midland and northern counties, where coal is cheaper, the cost of the same quantity of oxygen would be about 1*s.*, so that on the lowest estimate of 30 per cent. less bleaching powder used there would be a clear saving of 3*s.* or 4*s.* I am confident, however, that in fitting up a complete apparatus a greater economy—say 40 per cent.—could be effected, which would of course proportionately increase the money saving. I may mention that at a large mill where the experiments were made, and where about 150 tons of esparto are treated per week, the proprietors are so satisfied with the results obtained with the 50 tons experimented on that they are on the point of putting up plant. It is now only a matter of settling the details of agreements as to terms.

With respect to the question of gas purification, there are a good many points at which a saving may be effected. In the first place we may do away entirely with the oxide of iron. The saving in cost of oxide will be small, but the saving in space, handling, and so on is by no means small. We shall also be able to reduce even then the amount of lime used, and the space for the lime, which is very considerable, by nearly one-half. Consequently there will be a further saving on the handling of lime.

Then there will be another and appreciable saving in obtaining an increase of luminosity instead of a decrease in the purified gas. In the ordinary gas where air is used for the revivification of the oxide of iron, the gas almost always loses a certain amount of luminosity. It may be only half a candle or less, but it does lose. Where oxygen is used, there is an undoubted increase of about half a candle power. This increase is no doubt due to a trace of oxygen left in the gas, which is not sufficient (the total quantity used being very small—only about 6 feet per 1,000 feet of gas) to appreciably increase the rate of consumption of the solid particles of carbon in the flame, but is yet sufficient to increase its heat, and thus increases the luminosity.

Referring to Mr. Newlands' remarks, I appreciate the difficulty of the fusel oil determinations, and shall be as glad as he will be to find a satisfactory method of analysis. But in this instance I do not have to contend with the same difficulty as the ordinary analyst. I should be sorry to say that the 0·28 which I have written down is an accurate determination of the fusel oil. But I have the great advantage in this case that I am comparing the *same* spirit before and after treatment. I have not to deal with one fusel oil made in one distillery and another made elsewhere. The value of my results is relative rather than absolute, the same spirit having been analyzed in the same way before and after treatment by oxygen.

The method used was a modification of the Marquardt method. Most of the alcohol and part of the water was carefully distilled off in a Le Bel Henninger fractionating apparatus. When the temperature has risen to 93° or 95° C., the residue (which is almost free from ethyl alcohol) was treated by the ordinary extraction method with chloroform, oxidized with bichromate of potash and sulphuric acid, and the fatty acids produced were estimated in the ordinary way. Referring to Mr. Bevan's remarks as to the action of the chlorine on jute, I may say that to avoid carrying my paper into great detail I omitted one thing which might have been stated with regard to these experiments.

The action of the chlorine on the jute was not a complete bleaching action. In all cases, after treatment with chlorine, the jute required to be finished off with a dilute solution of bleaching powder. When the jutes came out of the chlorine chamber they were more or less orange colored, but they were so far acted on as to require very little finishing; and in my results, where comparison is made between jutes bleached with oxygen and chlorine and those where no oxygen was used, I was careful to keep the finishing solutions very dilute, and equal in quantity and strength. I quote that example as showing the absolute absorption of a very large quantity of oxygen during the bleaching process.

In answer to the question as to the permanence of the whiteness, I may say that, as far as can be judged, in all cases the oxygen-bleached materials stand better than those bleached with chlorine or bleaching powder. In the case of the jute bleachings this was very marked. We had samples bleached equally by the two methods. They were equal in color at the end of the experiment; at the end of four days the oxygen-bleached one retained its whiteness much more completely than the other. This was also the case when working on the large scale, and was noticed by the workmen.

When they got their wet pulp bleached on a Saturday night and it has to stand till Monday morning, they generally find it "go back" a little. One batch of oxygen-bleached pulp stood in that way, and the men remarked that it had not "gone back" at all. The question of loss of weight has been tested, and in all cases where oxygen has been used in conjunction with bleaching powder or chlorine the loss of weight has been considerably less—sometimes 50 per cent. less—than in the corresponding cases where chlorine or bleaching powder alone was used. Mr. Bevan asked if I had made experiments as to the action of oxygen alone. I have made a great number of such experiments—at high and low pressures and at high and low temperatures.

In some instances there seemed to be a very slight bleaching action, but in the majority of cases no change could be detected. I may say, therefore, that under ordinary conditions of simple mixture with or exposure to oxygen, I have as yet been unable to produce any change, unless a temperature was used too high for practical purposes and likely to damage the goods. Referring to the spent lime in gas purification, the sulphur is present partly as reduced sulphur, partly as sulphide, partly as sulphate, and partly also as sulphite.

The relative proportions appear to vary, but the actual ratios between them have not been much studied as yet. As far as can be judged, about a quarter to one-half the sulphur is always in the free state, the remainder being in combination. Mr. Sharp has referred to the relative cost of oxygen and hydrogen peroxide, and I can only add that the cost of hydrogen peroxide is so high at present that it can only be used for special purposes, such as the bleaching of ivory, where the action of such agents as chlorine would be detrimental, and where the users can stand the high cost.

Could we obtain hydrogen peroxide in a more direct way and at a lower price, no doubt there would be a great field for its powers as a bleaching agent. With regard to the action of oxygen on oxide of iron, converting it into magnetic oxide, I cannot give any information, our experiments having been directed in the first instance only to testing whether the increased action due to the oxygen was sufficient to make it worth using. We soon found that we were able to get rid of the oxide of iron, and our work after that turned exclusively to the examination of the purification by lime, and the products of the action of the oxygen have received but little attention as yet.

Dr. Wright asked about the action of oxygen on water. As far as the Oxygen Company is concerned, we have never claimed the purification of ordinary potable water by compressed oxygen. I do not believe that oxygen will have by itself any appreciable effect in purifying potable water. It may, either alone or in conjunction with other materials, be used at some future time for the purification of sewage and similar matters where the organic matter present is of a less stable character; but for improving a potable water containing only the ordinary contaminations there appears no likelihood of its having any value.

With regard to the replacement of chlorine by oxygen my experiments have shown that as we increase the proportion of oxygen to chlorine or bleaching powder, we improve the bleaching effect up to a certain point. When that point is passed the effect remains stationary for some time and then begins to decrease. In the case of chlorine and oxygen, an increase of effect has been noticed up to about two volumes of oxygen to one of chlorine. Up to three or four volumes of oxygen there is very little difference; but if we increase the proportion of oxygen beyond that, we get a loss of bleaching effect.

I fear I cannot give Mr. Wingham much hope of a purer paper. No doubt where the use of chlorine or bleaching powder is reduced, the paper is increased in purity and tensile strength. Whether or not the bad effects he has mentioned are due to chlorine remaining in the paper I cannot say; nor can I say whether they would be removed by the use of oxygen. It is probable, however, that the use of oxygen would produce an improvement in that direction, because the less chlorine there is used, the less action is there on the fiber of the paper.

ACTION OF SODA AND VARIOUS ACIDS ON COTTON.

M. ALBERT SCHEURER has recently presented a paper on the subject to the Industrial Society at Mulhausen, in which the following data relating to the weakening of the cotton fiber are given. Strips of unbleached cotton cloth, 4 cm. wide, were submitted to the action of solutions of caustic soda of different degrees of concentration, at a temperature of 150° C. for eight hours. Dynamometric tests were made on ten strips, both before and after immersion, with the following results:

Strength of solution.	Mean resistance of ten tests.
10 grammes of soda per liter of water	16·4
20 " "	16·6
40 " "	15·8
80 " "	16·8
Original cloth	16·9

Under these circumstances, therefore, caustic soda, even when used in solutions containing 80 grammes per liter, does not weaken cotton fibers. It had been observed in some previous experiments that the presence of air bubbles protected the cloth from the action of solutions, and, in the present instance, the cloth was moistened with alcohol before being submitted to the caustic lye. By this means, the absorption of the solution by the fibers was facilitated, and the effect of air bubbles avoided. The action of gaseous hydrochloric acid was next tried. A small quantity of concentrated hydrochloric acid of commerce was poured into a vessel, and pieces of bleached cotton cloth were suspended in the vessel above the liquids, so as to be exposed to the fumes only. The experiments were conducted at the ordinary atmospheric temperature, about 20° C. The very injurious action of these acid fumes will be realized from a perusal of the following figures:

Period of exposure.	Mean resistance of ten tests.
Before exposure	24·3
After 10 minutes	15·0
" 20 "	14·6
" 40 "	9·6
" 80 "	6·0

It will be observed that, even within the small space of ten minutes, the cloth had suffered considerably, while after one hour and twenty minutes it had become practically worthless. Similar experiments were made with gaseous nitric acid, or nitrous fumes. Commercial nitric acid, 36° Bé., was employed, the experiments being otherwise the same as those with hydrochloric acid. The results were as follows:

	Resistance.
Before exposure	24·3
After 10 minutes	21·7
" 40 "	18·7

It would, therefore, appear that although nitrous fumes are very injurious, they do not damage cotton fibers to the same extent as hydrochloric acid fumes do, when the cloth is exposed to each for the same length of time, at the same temperature and atmospheric pressure. It must, however, be remembered that the tension of the vapor of commercial hydrochloric acid at 19° Bé. is greater than that of nitric acid of commerce at 36° Bé.; therefore the latter acid would be more rarefied or diluted than the former in the atmosphere of the vessel in the above experiments. Therefore the results only represent the measure of the comparative action of the vapors emitted by the two liquids under the stipulated conditions. The results of experiments with sulphuric acid are given in the next table. The cotton before treatment had a resistance of 24·4. The solution contained 2 grammes of 66° sulphuric acid per liter of water. The cotton fabric was immersed in this solution at a temperature of 83° C. in the first instance, and of 90° C. in one lot of experiments, with the following results for different periods of immersion:

	Resistance.
1. Not treated	24·4
2. After 15 minutes	24·0
3. " 30 "	24·0
4. " 30 "	22·0
5. " 30 " at 90° C.	20·1
6. " 30 " at 83°, with solution containing 4 grammes 66° sulphuric acid per liter of water,	22·6

These samples were afterward subjected to the action of a boiling solution of sodium carbonate for a

quarter of an hour, containing 2 grammes of the salt per liter of water. The resistance was then tried, with the following results:

Sample 1	24·1
" 2	23·5
" 3	22·6
" 4	17·9
" 5	20·1
" 6	21·5

These tests with the sulphuric acid at 80° C. indicate that the weakening only takes place after half an hour, whereas at 90° C. the action is much more energetic; but the subsequent boiling with sodium carbonate reveals a loss of strength increasing with the length of period of immersion in the sulphuric acid, while no excessive weakening is observed following exposure to higher temperature.

COMPOSITION AND SELECTION OF A SUBJECT.

By TRISTRAM T. ELLIS.

IF two artists choose the same subject, as frequently happens at well known places abroad, and both are conscientious workers, it is, nevertheless, very unlikely that they will produce pictures at all like one another, though both may be equally like nature; generally one will be much better in composition than the other, simply because the artist who did it knew most about composition, and therefore chose his position best. This is even more the case with photography than sketching. We frequently see photographs of places that form the most charming pictures, but more frequently we find them not forming any picture at all, though we all know their subjects to be beautiful.

A knowledge of composition is very important, and even a few rules are useful. The two sides of a picture should nearly balance each other, either in interest or mass, or both combined.

The most pleasing compositions are those where the masses do not balance each other, but the smallest

FIG. 1.

mass should have the greater interest. One of the simplest forms of composition may be seen in an egg laid sideways and illuminated by one point of light. A mere egg could scarcely be called a picture, but Fig. 1 is one, because the distance on the left is sufficiently interesting to balance the strong mass on the right. In this instance dark is taken encircling light, but the reverse is equally good, as in Fig. 2. When the composition of the ground is unavoidably one-sided (as in almost any view of Gibraltar, for example) interest may be given by clouds, or by large figures in the foreground, or both (Fig. 3). The great use of foreground figures is to add an interest to the picture in the right place.

In Fig. 4 is a drawing of the Porte Saint Croix at Bruges, a delightful old gate, and full of lovely color; yet when drawn by itself it is one-sided in composition, and poor as a subject. To centralize the picture, introduce to the right one of those old Flemish barges so often seen on the canals in Belgium (see Fig. 5). A piece of sail cloth has been spread to protect the steersman from the hot midday sun. It is now late afternoon and the barge has come to rest for the night, and is moored to the right bank. The womenkind have taken the opportunity for washing clothes, and the sailors are looking after the condition of the rigging. This concentrates the interest too much on the barge, and to make a picture we must have minor interests in other parts also. We will, therefore, introduce a cart going into the gate, and more barges moored on the other side. Finally, white clouds are put in, with the greatest mass behind the dark mast of the front barge, and our picture is complete.

A picture or sketch may be composed by lines as well as masses; such as *Calais Pier* and many others by Turner. The lines should always be in curves that have a tendency to run to two balancing points. The curves should, if possible, never be a part of a circle, but be some irregular yet true curve, tending toward

FIG. 2.

parts of ellipses, hyperbolas, or cycloids. Such curves we can trace in Fig. 5.

To form a good composition, not only the masses combined with interest must balance, but the light should be as much concentrated as possible on one point, and the shadow on another. The egg is a perfect example of this, but is too rigid for pleasantness, and all rules must be a little elastic. It is a great mistake to *force* the light and shade into points unlike nature, but the subject should be chosen so that it does so of itself.

In nature, unless the subject is artificially illuminated, the light has a tendency to arrange itself in planes of different values. Thus, the sun shining straight on to a flat field illuminates it nearly equally all over; and it is a bad and false system to improve upon nature by lighting the field strongly in one central spot and keeping every other part lower in tone.

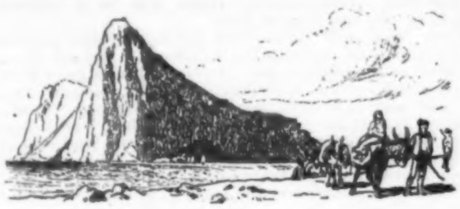


FIG. 3.

It is unfortunate for beginners in art that so great a man as Rembrandt should have practiced this system of grouping lights and shades to the extent he did. It is extremely fascinating, and inside a room or house it is perfectly just and true, but in the open air, and especially in sunlight, it is never true, though Rembrandt, who had contracted a habit of lighting his pictures and figures this way, actually carried the same out in his picture, the *Good Samaritan*, in the Louvre. So much worshiped is this great man that any number of excuses have been framed for this untruth, and it has been copied by modern artists over and over again. The vicious habit of *forcing* the lighting of a landscape is much indulged in

FIG. 4.

by the modern French and Flemish schools. French artists, with whom the writer has expostulated upon its great prevalence in their school, admitted freely that it was not in nature, but argued that it was necessary for a picture that it should be so arranged. It is a rough-and-ready way of getting interest concentrated on one spot where it would not be otherwise; but as it is artificial it should not be practiced, especially by a student sketching from nature.

That it is not necessary to a good picture is amply proved by many of the best English and French landscape pictures; those by Millais, Daubigny, and others do not contain it. Yet if the light happens to be concentrated in nature upon one spot, as in a deep wood, or between lofty crags, or where a gleam of sun passes between a rift in dark and stormy clouds, then it is beautiful, and should be copied exactly, for it is natural and not forced. For this concentration of light is a beautiful thing in itself, but when it could not possibly happen in nature its effect is totally incongruous and militates against truth and good taste. It is not uncommon to see in France moonlight pictures wherein the light falls full upon a flat field on which, near the middle, are some figures. The artist often concentrates his light on one spot near the dark figures to such an extent that to be natural the ground must be almost in a liquid condition. It is very effective, but such a "dodge," for it can be called by no other name, should be avoided.

Of course, when the greatest dark and highest light

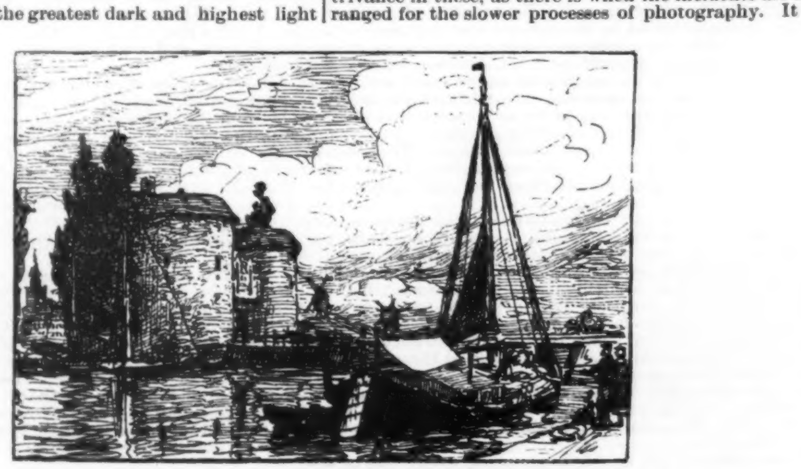


FIG. 5.

come in juxtaposition, the strongest effect is produced in a picture, yet this should always be got naturally, not artificially. We have it in Fig. 2, where the figures come against the sunset.

Some of the easiest things to group are boats and ships upon the sea. They may be placed anywhere. The different colors of the sails and hulls permit the lights and darks to be grouped even when everything is in the full glare of the sun. The play of light upon the water, the forms of the waves if the sea is rough, and the reflections when it is smooth, all lend themselves easily to grouping of the most complicated and delicate kinds.

In all compositions there should be one chief point of interest. If it is large, there is no limit to the number of subsidiary points of interest, graduating from the principal one down to those that are of very little value. In a sketch it is advisable not to put too many points of interest, especially for a beginner, yet he should always have more than one. This may be taken as marking the difference between a study and a sketch, for in a study the only thing aimed at is to do some particular thing with the utmost realism. The study of a figure will be of the figure alone, but a pleasing sketch of the same will introduce some characteristic feature of interest in the background or foreground. For example, a man asleep, who by himself would be sufficiently uninteresting, by the addition of surroundings a most charming and interesting sketch is made. We learn that as there is no wind he has fallen asleep at the tiller, from having nothing to do. The near sail hangs idly; a small boat is drawn up on the beach, and there is not a person moving. A delightful little incident, carrying out the calm of the picture, is the motionless windmill at the top of the slight rise in the distance.

A sketch of a tree would have some other trees lightly indicated behind, some sheep in the shade, birds or other object. A sketch of a cottage might have some one coming out of the door. A sketch of a ship might show sailors aloft, a little boat on the sea near, or scudding clouds overhead, with seagulls sailing through the air.

But it is not necessary to have life in a sketch. There is a charming little sketch of a wheat field by Mr. Marks, wherein the trees in the background, with the field beyond, and the numerous little stooks, go to make it full of interest, though there is no life whatever.

In all composition we should be careful not to put in incidents that are not likely to take place in nature, such as an elaborately clouded sky with the landscape below in full sun; huge pieces of wreck from an old line-of-battle ship of a hundred years ago in the foreground of a picture of modern boats painted only yesterday; Bedowee, in full fighting costume, with long guns and still longer spears, riding up a street in Cairo or Jerusalem; or an Italian peasant in gala costume working in the fields. Or again, in landscapes with strong effects, do not put long and strong shadows on the ground in a picture where the sun's disk is already half down, or bright high lights on the edges of things just below the moon, when near the horizon, or a ship in full sail running fast through calm water, etc. Many other examples might be quoted of most common mistakes, that show a total disregard of what is likely to happen in nature and a gross ignorance and complete want of careful study and thought.

In former times nature never seemed enough for the artist. He always added to it to make it richer than he found it. Now we know a picture may have all the requirements of a good composition and yet may be perfectly natural. The great spread of instantaneous photography has made this abundantly plain. If we look over a number of instantaneous photographs, we may pick out many that in composition and effect are beautiful pictures, and there is no possibility of contrivance in these, as there is when the incidents are arranged for the slower processes of photography. It is curious to notice how, the less the figures are aware that they are being taken—in other words, the more natural the composition is—the more beautiful it often becomes. Not but what there are many more examples of bad than good composition, but when it is good it has a charm about it that is only possessed by the works of the greatest masters.

We have already stated that shipping composes itself easily. This is very well seen if we look at a number of instantaneous photographs of water subjects. We can generally pick out some good ones.

SELECTION OF A SUBJECT.—It is strange what a long time it takes before the beginner can learn to choose a subject that composes well. Details attract him too much, such as a splendidly rugged trunk, a beautiful group of flowers, a charming reflection, or a most rustic cottage, which one and all rivet his attention regardless of surroundings, and he is surprised when his sketch is done how poor and uninteresting it looks if put upon a wall or beside other and better compositions. We should always regard general grouping first, and special interest of detail later. An admirable way of doing this is to half close the eyes, which causes the general grouping of lines and light, shade and color, to become more easily visible on account of the attention not being drawn off by the detail. It is also a great assistance to put up the arm in front of the face, holding the part from the elbow to the wrist horizontally, and to move it up and down until you see where the subject had better be cut off for the bottom of the picture. Then the other hand may be moved along it vertically to see where the sides had better come.

Sometimes the subject seems a beautiful one, as a rich and splendid bit of heather in full bloom, with perhaps some cottages and fir trees at a little distance, rather on one side, and distant hills beyond. Yet we find it will not compose into an interesting picture, and we try in vain the moving of one arm up and down, and of one hand backward and forward. Suddenly a man and loaded donkey emerge from the cottage gate and come slanting across the picture toward us, a little child stopping at the door to see him off. Immediately a good composition appears, and we only have to copy that to secure our picture. However, most probably nothing appears at all, and then we have to put our man and donkey in from some other place, but till we have imagined him it is as well not to begin our sketch unless it is indeed a mere study of heather to be used on some future occasion. In such case it should be made as finished and careful as possible, so that in copying it we should approach as nearly as may be to working actually from nature. A study is then always done for a special purpose, of use, and ought not to be shown. You may do it to improve yourself in drawing a special thing, and may make many of them, but only show them to a master, or some one from whom it is desired to get information, and not for the purpose of giving pleasure to others, for in that you will certainly fail. A study may be produced for the purpose of using it afterward when painting a picture, but this is going beyond the function of this book to consider.

The French consider that a landscape is no picture unless there are *three planes* or parts—the first plane or foreground, the second plane or middle distance, the third plane or extreme distance. An endless variety may be given to the composition by varying the size and importance of the three planes, but they should always be there.

If the *third plane* is missing, a close and shut-in feeling is produced. A little peep of distance should be got in somehow or other, though if this cannot be done, a fine sky will sometimes act as a third plane.

If the *second plane* is not seen the effect is theatrical. Though in nature occasionally, as in mountain scenery, we may have a fine landscape without a visible second plane, we know and feel it must be there. This feeling cannot be put into a picture, but it can be suggested by an eagle or floating cloud.

If the *first plane* or foreground is omitted, all strength goes out of the picture.

Lastly, if *both* the second and the third planes are wanting, the sketch is neither landscape nor picture, it is only a study. And even in a mere study (to be used, perhaps, as a background for figures) there had best be some break or hole, some gap in a hedge, an open gate or a window in a wall, through which you can catch a glimpse of distance.

The advice of a celebrated picture dealer to a young landscape artist was: "Never paint a picture with a shut-in composition. People inside rooms like to have pictures which, when they look at them, they can imagine themselves seeing *out of* to something fresh and bright beyond."

To *choose a subject* well you should perpetually think of how it will *compose* in your sketch, either with or without the accessories of figures or strong effect. The most interesting sketches are those which depend upon effect or figures for their strength.

Figures play so important a part in composition that it is as well to consider them separately.—*Sketching from Nature.*

DETECTION OF ADULTERATIONS IN VOLATILE AND FIXED OILS BY MEANS OF ABBE'S REFRACTOMETER.*

By SAMUEL P. DUFFIELD, Ph.D., M.D.

PROF. ABBE, of Jena, brought before the Jena Society of Medicine and Natural Sciences, in 1879, an improvement upon all former refractometers. By means of Prof. Abbe's improvement the refractometer becomes of service in detection of optical quality of fluids and also of solids. By the original construction of this instrument the *total reflection* which a thin film of transparent substance shut in between two glass prisms shows is made available for discovering the exponent of refraction of light, as also to get data for calculating its dispersion. The advantages which this method has over the method of Wollaston lies in the fact that while his method only permitted the examination of fluid bodies by total reflection, Prof. Abbe's first refractometer contained a principle which was destined when more fully elucidated to solve the problem of also reaching with the same instrument the index of refraction of solids as well as of fluids. Kohlrausch had constructed an instrument called by him total reflectometer (Annalen d. Physik und Chemie, Neue Folge, Bd. IV., pg. 1), and this proved the stepping stone upon which Prof. Abbe rose to the construction of his improved instrument.

Before I describe the instrument allow me a few words as regards light itself—as it will be necessary for you to understand the working of the refractometer to know something about light. It is certainly a fact that the ancients had, according to our present knowledge, a very crude idea of light. The earliest theory, which is now called the "corpuscular," originated with the disciples of Pythagoras, who taught vision is the result of particles or films emanating from the surfaces of visible bodies and entering the eye. This theory was met by the Platonists, that vision was due to the emanation of an influence from the eye itself. Both of these theories have fallen as valueless, the Pythagorean or corpuscular receiving its death blow from our own countryman Franklin, who showed that if the particles were material they would have weight, and if they had weight they would from their immense velocity inflict such blows upon the eye that its delicate structure would soon be injured and destroyed. There remained then but one course for philosophers to pursue, and that was to follow the line marked out by Huyghens and the celebrated mathematician Euler, both of whom held that light, like sound, was the result of *wave motion.*

Laplace, Malus, Biot, and Brewster supported Newton, and the theory of Pythagoras commonly known as corpuscular fought its way until it found its Waterloo in the labors of Thomas Young and Augustin Fresnel. These two eminent philosophers, while adducing whole classes of facts not explicable by the Newtonian theory, succeeded in establishing the most complete parallelism between the motion of light and the waves of sound.

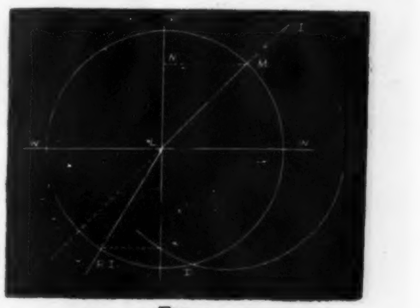


FIG. 1.

The justification of a theory consists in its complete explanation of all the phenomena, and as all the phenomena of light admit of satisfactory mathematical explanation as regards double refraction and polarization, it has been called, after that of gravitation, the most comprehensive and happy of all the hypothetical generalizations of physical science.

On the other hand, the necessity of having to suppose an ether to transmit these waves of light has called from Rankine, of Glasgow, the view that possibly a force acting upon particles at a distance, and having opposite polarity, would more fully explain matters. Nevertheless the wave theory has been deepening its foundations and making them more secure, and, until we can find a better one, proved so mathematically, we must take it in explaining the working of the refractometer. The instrument and the principles of its working are shown in the several cuts. Fig. 1 will aid us in describing a ray of light.

Let W W represent a section of the reflecting medium. I I the incident ray. L R the refracted one. Let P L Q be the perpendicular to the refracting surface. Passing through the point of incidence L, with any radius, L R, described from the center L, the circle R M P, from M and R, let fall the perpendiculars M N and R Q on P Q. M N will then represent the sine of angle of incidence, I L P, and R Q the sine of the angle of refraction, R Q L. M N ÷ R Q gives the index of refraction, which is the same for the same substance, whatever be the angle of refraction. In the diamond for instance M N is always 2½ times as long as R Q. In water it is 1⅓ times the length of R Q.

This is the instrument (see Fig. 2). It consists of a double prism and a telescope, and in the telescope are two prisms called amisee prisms, which are intended to polarize the light. The numbers 1·3, 1·4, and 1·5 (see Fig. 3), with decimals intervening, represent the indices of refraction on the sector, C. The drum, A (Fig. 2), is rotated until a perfectly colorless light is obtained. When you look through any volatile oil put into it between the two prisms, you will find the different colors of the rainbow, violet, indigo, blue, green, yellow, orange, red, in other words, the spectrum. You turn the thumb screw just above the drum, A, until you reach the point at which there is a dark shadow, but colorless on its edge. Inside there are crossing lines or filaments like those in a surveyor's instrument, so that you can bring the shadow which falls by the refraction of the light up to the crossings of the square lines, as soon as you reach the point of cutting evenly across the square line, which is done by moving the prism by means of the sliding index, B (Fig. 3), on the sector, C. Moving the prism, we reach the point in which the shadow, caused by the prism, up through the telescope, runs across the four lines and cuts them evenly across. We call that the point of reading, and by turning the drum, A (see Fig. 2), around we render the field of view perfectly colorless, and you then read it. Then you turn the instrument upon its side and read the figures on the sector, C, which gives you virtually the index of refraction. The old way was to get the angle at which the prism stood, and by calculating the angle of refraction you arrived at the result and reached what was called the index of refraction. Now Prof. Abbe has so arranged his instrument with the movable index, B, that we have the index given us without any calculation. The ray of light is bent in passing through the prism from its direct line in this way (see Fig. 1), L–R–Q, forming the angle of refraction. The angle of incidence is represented by M–N–L. The sign of the angle of incidence divided by the sign of the angle of refraction gives you the index of refraction. To make these calculations on paper would require from two to three hours, while with Abbe's instrument it is done instantly by the motion of the index attached to the prism. The sector reads from 1·330 to 1·650 index of refraction. Wollaston reached the same result in his method. He constructed an instrument with the sights, S, S (see Fig. 4), similar to those of a gun. He looked into the square prism, P, and another prism was placed back of it, the light striking in from (arrow). By moving index, G, back, sliding it upon A, B, the index ran along F, G, and as this was divided into 16 inches, he could read the inches and proportion, and that gave him the index of refraction. The lengths of the pieces, E, F, and D, E, are proportional to the refractive powers of the prism and of air. This was called a total refractometer. Prof. Abbe, by putting the oil of peppermint, tansy, wintergreen, sassafras, or any other volatile oil between the prisms in his instrument, reaches a result at once according to the principles laid down.

FIG. 3.

You will remember we had quite a discussion in this city on dementholized peppermint oil. There were certain samples of oil sold in this city through some men who are manufacturing peppermint candies, and the *Free Press* made the statement that a certain amount of dementholized oil had been sold. It was found that most of the oil had been used, and the gentleman who sold the oil, thinking *all* of it had been used, sued the *Free Press* for libel, claiming heavy damages. It became the duty of myself, and other experimentalists, to find out whether that was pure or impure oil; whether dementholized or not. Nothing but treatment by the polariscope and by the refractometer could detect it; of course you can detect dementholized oil by getting it below the freezing point, but to prove beyond doubt that it is not, the refractometer alone will give you the index of refraction of ordinary oil, and will reveal an oil that is adulterated with oil of camphor or anything else which has a different index of refraction. But the great difficulty with dementholized oil lies in this, that the refraction of the oil itself is almost equal to the refraction of the menthol, and we found it very difficult to find much change in the refraction of the oil after the menthol was taken out. It is only by distillation of the peppermint oil that we reach that point.

I give, side by side, the behavior of the impure dementholized peppermint oil and also a sample of A. M. Todd's pure oil, in the refractometer at ordinary temperature of 70° Fahr.

FIG 2.

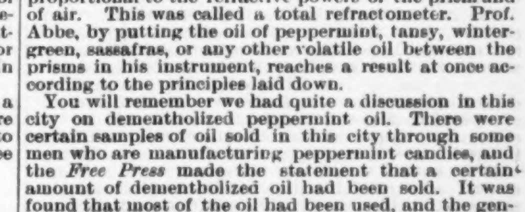


FIG. 4.

* Read before the Michigan State Pharmaceutical Association, at its meeting in Detroit, September, 1888.

Fractions.	Index Refractometer. Mean of Impure Oil.	Index of Refrac. Pure Oil.
1	1·46600	
2	1·46000	1·47000
3	1·46202	1.47220
4	1·46402	1·46305
5	1·46302	1·46255
6	1·46400	1·46305
7	1·46250	1·46355
8	1·46402	1·46505
9	1·46402	1·46550
10	1·46700	1·46600
11	1·46904	1·51405
12	Too dark.	Too dark for estimation.

You will notice the first distillation shows 1·466, while the first refraction of *pure* peppermint oil distilled was 1·470. Second refraction 1·460, and second refraction of pure oil 1·4722. The third is 1·46202, and the third of pure oil is 1·46305. Now, what makes the difference? There was a certain oil of camphor in the beginning, showing that the index of refraction in pure oil was entirely distinct from the index of oil that contained the oil of camphor. This was carried on until we reached the tenth fraction. The dementholized oil reached eleven fractions, while the pure oil reached only ten. We could not test it all, it was too dark. The way to use the refractometer is: Turn the thumb screw to the left to bring the ray perfectly colorless, then take the index of refraction, then turn it to the right and take the index of refraction, and then get the mean by adding these and dividing it by two, giving 1·46502 (see table below).

IMPURE OILS.

35½ R., 1·46500
36½ L., 1·46505

2)2·93005

1·46502 = mean.

The real difference then in the reading of the two is only 0·00002, which is very accurate. We have the mean of the impure oil carrying camphor 1·465, while the pure or double distilled oil is 1·462 or 1·463. It is not only of value in testing volatile oils, but also the fixed oils, for instance, linseed oil. Cottonseed oil and linseed oil mixed registers at 1·477, and 75 per cent. of cottonseed would be 1·474. The index of cottonseed oil is so much more than the index of linseed oil that I will defy any man to put cottonseed and linseed oil so together that I cannot detect them. There are instances where the refraction in lard oil is so much like butter that another treatment is necessary. Sometimes in the analysis of butter it becomes necessary to take the Reichart method.

SPECIFIC GRAVITY.

Temp. C. 100°.

Lard.	Margarin.	Butter.	Butterine.
0·8605	0·8601	0·8598	0·8672

REFRACTOMETER.

Temp. C. 20°.

Lard.	Margarin.	Butter.	Butterine.	Cottonseed Oil.
1·4690	1·4692	1·4652	1·4693	
		1·4650	1·4733	1·4748

You will notice that the index of refraction for butter varies quite plainly from the margarin and butterine, showing that a sharper dividing line can be drawn by means of the refractometer. But in order to be sure of having the right index of refraction, you must be careful to see that all moisture is evaporated and you are dealing only with the dehydrated fats or olein. As evidence of this I cite an experiment made with fresh butter which was placed upon the warm prism and as soon as melted the index of refraction was taken and it read only 1·459; a sample of oleomargarin was also taken and it read exactly the same. On heating them for 12 hours in a water-drying oven the results were entirely different. Where we have oils with refractive indices nearly alike, as for instance:

Cod liver oil....................	1·4801
Linseed oil........	1·4820
	2)2·9621
50 per cent. of each	1·48105

Now we could be sure this mixture or an oil having the index of 1·48105 could not be pure cod liver oil, but at the same time we could be thrown into doubt as regards linseed oil, for it varies from 1·4820 to 1·4835, according to the temperature.

How beautiful is the idea that almost all adulterations will be shown by the ray of light as it comes to us from that glorious globe, 14,000,000 times larger than the one on which we stand. Those of us who realize that there is a Creato rare ready to exclaim: "Knowest thou the place where light dwelleth, that thou shouldest take it to its bound or understand the path to its house?"

We know yet but little about light. It certainly, if not considered eternal, is to be viewed of all physical forces as the nearest related to Deity, for "His robe is the light."

This instrument is expensive, having cost 230 marks plus the duty of 25 per cent., but there is a smaller instrument made that will meet all the requirements of druggists who do not care to calculate the dispersion of light, but wish to use it only for volatile oils. It costs about 105 or 110 marks and registers from 1·30 to 1·65, and is of practical service to the pharmacist.

I would call your attention to the fact that in using the instrument you must begin with the refractive index of a pure oil. You must know it is *absolutely* pure, because this is the basis on which all other experiments are made. If you start with impure oil, you will be calculating on an impure basis. The question arises, What is there to certify that the instrument is correct? A drop of distilled water placed on the prism will read on the index of refraction 1·330, and you always adjust your instrument at the ordinary temperature to 1·330 distilled water. That is your starting point. Your instrument is correct when it reads that way, and the next thing is the pure oil. Many of the oils sold as pure, for instance, the true cinnamon oil and the oil of nutmeg, show adulteration with some oil with a lower index of refraction than the true oils. The instrument tells you the absolute purity of oils, and when one becomes thoroughly familiar with its workings, he can, in five or ten minutes, tell whether an oil is pure or not.—*Pharmaceutical Era.*

EXPERIMENTS IN EQUILIBRIUM.

Take two bottles of the same height, and insert in each of them a cork that has been beveled on two opposite sides at the top, and then place the bottles upon a table at a certain distance apart, and in such a way that the edges of the top of the corks shall be parallel. Upon each cork place a table knife, the blade resting

EXPERIMENT IN EQUILIBRIUM.

upon the edge of the cork through the part near the handle, pointing outwardly, and so that the two blades shall be directed toward each other without touching. Upon holding the two blades between the thumb and forefinger, the two knives will remain horizontal. With the other hand take a thin glass (a wine glass, for example) half full of water, and place it upon the two blades. After a few tentatives, either in shifting the position of the bottles or varying the quantity of water in the glass, it will become possible to keep the glass upon the blades without the aid of the hand. If a few drops of the water be removed, the glass will rise slightly with the blades, and assume the position shown in the accompanying figure.

If now a thread be taken from which is suspended a small weighty object, such as a metallic button or leaden ball, and such object be immersed in the water, the glass and blades will be observed slowly to descend. At this moment, if the thread be drawn gently upward, the glass will rise and seem to obey its motion.

If, in this way, the hand be successively raised and lowered in a regular manner, the glass will take on a vertical oscillatory motion, as if it were suspended from the thread, and begin to dance like a genuine marionette.

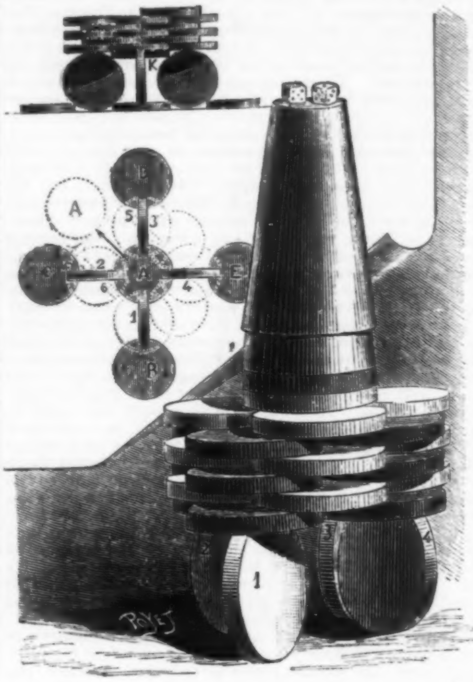
ANOTHER EXPERIMENT IN EQUILIBRIUM.

The accompanying engraving illustrates an experiment that may serve to test the patience and skill of a person who wishes to pass away his time while awaiting a partner in a game of backgammon. The question is to place the thirty men of the game upon four independent men standing on edge.

The solution of the problem requires a series of ingenious and even somewhat complicated combinations; so whoever wishes to try to solve it will do well to provide himself with a set of backgammon men, and, pieces in hand, follow us step by step in our explanation.

Lay the central piece, A, flat upon the table, and, on the prolongation of two diameters at right angles, place upon edge the pieces, 1, 2, 3, and 4, which are to support all the rest. In order to assure of their contact with the upper edge of A, it is necessary to chock them temporarily with the four pieces, B, C, D, and E, laid flat upon the table.

Now place a piece, K, horizontally upon the edges of the pieces, 1, 2, 3, and 4. This done, place four pieces in such a way that their centers shall be respectively over the centers of the pieces, B, C, D, and E. This gives us the first horizontal row. The second row is obtained by placing four more pieces horizontally upon the four preceding ones, but so alternating them that the centers of the pieces of the second row shall be over the spaces existing between the pieces of the first row.



EXPERIMENT IN EQUILIBRIUM.

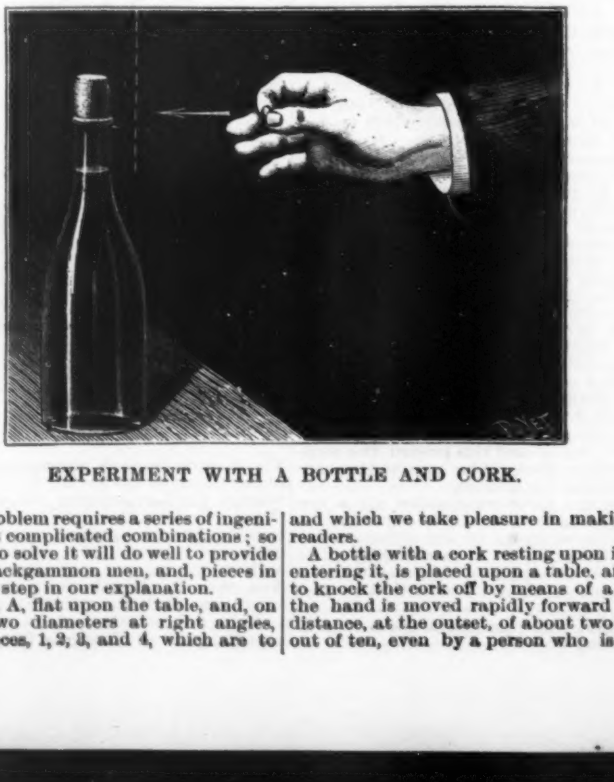
Continue alternating thus to the fifth row, the pieces of the odd rows (the black, for example) being situated directly over each other, and the pieces of the even rows having their centers likewise upon four vertical axes passing between the spaces of the columns of odd rows. The five rows dispose of 20 pieces.

Up to this point it has sufficed to operate exactly according to our directions, and no difficulty has been met with. But here is where the operation becomes ticklish. It is a question, in fact, not only of removing the pieces, B, C, D, and E, serving to chock the vertical pieces that are alone to support the structure, but also to free the two pieces, A and K, that the pieces, 1, 2, 3, and 4, hold prisoners. How shall it be done? Let us first get rid of the pieces, B, C, D, and E, and, having formed the sixth row with them, let us occupy ourselves with the two prisoners.

Upon the plan to the left remark the figures 5 and 6, placed alongside of two parallel dotted lines. These lines represent the oblique position which it is necessary to give the pieces, 2 and 3, temporarily, by deftly turning them with the finger. The piece, K, being no longer supported, falls upon A, and the two pieces, A and K, can be withdrawn though the space thus created between 2 and 3. Having placed A and K upon the sixth row, and in the center of it, return 2 and 3 to their original position, and cap the whole with the two dice boxes of the game of backgammon, one inverted over the other and supporting the two dice.

ANOTHER EXPERIMENT.

One of our readers, Prof. P. Dumont, of Nancy, communicates an experiment which appears interesting, and which we take pleasure in making known to our readers.



EXPERIMENT WITH A BOTTLE AND CORK.

A bottle with a cork resting upon its mouth, but not entering it, is placed upon a table, and the question is to knock the cork off by means of a fillip given while the hand is moved rapidly forward from a horizontal distance, at the outset, of about two feet. Nine times out of ten, even by a person who is familiar with the

experiment, the fillip will be given in space and above the cork. Two causes concur in such failure: First, it is the instinctive fear of upsetting the bottle by striking the neck at too low a point—a fear that will be increased if the table has a marble top, upon which the bottle would run the risk of being broken upon falling, or if the experiment be performed upon a table upon which dishes are laid, where it might cause other damage. Second, and more especially, it is the fear, due to the solidity of the bottle, that the fingers may be hurt by coming into abrupt contact with the glass.

The following experiment of the same nature may be mentioned. Place a match upon a table top having a sharp edge, in a direction at right angles with the latter, and so that it shall project about an inch from the table. Now the person who endeavors to knock the match off the table by a strong blow of the hand held vertically will in most cases fail in his attempt, for the second of the reasons above mentioned.—*La Nature*.

SIBLEY COLLEGE LECTURES.—1888-89.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

IV. THE LABORER AND HIS EMPLOYER.

By FRANCIS A. WALKER, of Boston.

GENTLEMEN: The nature of your studies intimates that many of you are likely, in your professional lives, to have to deal, more or less closely, with considerable bodies of laboring men. It is this which has suggested to me the subject of my remarks this afternoon: The laborer and his employer. The theme is one which, from its general social and political interest, must command the attention of every educated man; but it makes peculiar demands upon those who are called to administer large bodies of labor and capital, or to give advice concerning industrial enterprises.

It is the more worth while to speak freely and with iteration on this topic because the great majority of the text books and treatises on political economy which are to be found on the shelves of any library contain views regarding the relations of the laborer and his employer which are opposed to the general opinion of the economists of the present time; while, by the force of tradition and prescription, doctrines now rejected by all advanced thinkers are almost daily repeated by those who are accustomed to teach and to preach at second hand. The newspapers and the reviews abound in expressions of opinion, from writers who learned their own lessons in the schools of a half a generation ago, which show them to be serenely unconscious of the great change that has recently passed upon economic thought.

The now discarded doctrine regarding the relation of the laborer to his employer may be styled the doctrine of the trusteeship of capital. It was but a short time ago almost universally held that, in order to an equitable and beneficent distribution of the product of industry, it was not needful that the laboring class should actively concern themselves regarding their own share in that distribution. It was explicitly taught that, even if the laborers did not seek their interest, their interest would seek them and would find them. Through economic harmonies, never to be sufficiently admired, all classes, high or low, rich or poor, strong or weak, were bound up together, in such quick and vital communication as to secure each by turns from injury at the hands of any other. In such a happy industrial state, it was held that the employing class, alert, intelligent, constantly informed as to the conditions of the market, with, moreover, the largest stake in the result, could safely be left to determine the proper wages of their workmen, their own interests requiring them to pay the most that could, with prevailing prices, possibly be paid. Even unfair methods and a grasping spirit could not, in the final result, diminish the remuneration of labor.

That it may not be thought that I caricature the doctrine in question, I will quote the statements of it by two economists, one in England and one in America, made even after the doctrine had been seriously called in question.

"Unless," said Prof. John E. Cairnes, having in view the forcing down of wages by a combination of employers, "unless we are to suppose the character of a large section of a community to be suddenly changed in a leading attribute, the wealth so withdrawn from wages would, in the end and before long, be restored to wages. The same motives which led to its investment would lead to its reinvestment; and once reinvested, the interests of those concerned would cause it to be distributed among the several elements of capital in the same proportions as before. In this way covetousness is held in check by covetousness, and the desire for aggrandizement sets limits to its own gratification."

"If, in the division between profits and wages," said Prof. Perry, "at the end of any industrial cycle profits get more than their due share, those very profits will wish to become capital, and will thus become an extra demand for labor, and the next labor fund will be larger than the last." And the same economist wrote elsewhere:

"If capital gets a relatively too high reward, nothing can interrupt the tendency that labor shall get, in consequence of that, a larger reward the next time. If capital takes an undue advantage of labor at any point, as unfortunately it sometimes does, somebody, at some other point, has, in consequence of that, a stronger desire to employ laborers; and so the wrong tends to right itself."

According to this theory of wages, not only was it not needful that the laboring class should do anything toward securing their own interests, but it was even undesirable that they should attempt to do any such thing. Competition among the masters having the effect to give to their laborers the highest wages that could possibly be paid and maintained, anything which the laborers might attempt, on their own behalf, would at the best be nugatory, and was likely to prove mischievous. With his lower order of intelligence, with his narrower outlook, with his nearer horizon, over which the clouds of prejudice and passion were more likely to settle than in the case of the employer, the workman was deemed to be far less qualified for discerning the master's true interest than the master himself, and the master's true interest was also the workman's. All the laborer had to do was to patiently await the resort of the employer to his door, were he at the time out of employment; or patiently to await the inevitable rise in wages which any undue profits on the part of his employer would speedily bring about. If, on the other hand, the laborer were to undertake to meddle in the matter, he could do no good; he might do great harm alike to himself, to his employer, and to the community, should he, by combination with his fellows, for the time force up the rate of wages to a point incompatible with due profits to the employer. On the last point it is curious to observe that it does not seem to have occurred to the writers on the economic harmonies that, if excessive profits were certain to be restored to wages, it might also happen that excessive wages would be restored to profits. It is said to be a poor rule that does not work both ways; yet, in the matter before us, these writers neglected to inquire whether the economic harmonies would not protect the employer from the effect of greed and covetousness on the part of his workmen. On the contrary it was taught that, if the laboring classes, under the influence of a grasping spirit, and acting through combination, should succeed for the time in forcing wages above the proper point, something very disastrous, if not fatal, would result to trade and industry. Strikes, in particular, were denounced as always and necessarily evil, having no economic function, and being simply the result of wrongheadedness or the spirit of mischief.

I believe I have stated the once generally accepted doctrine regarding the relation of the laborer to his employer, not unfairly, though without the dignity of expression and elevation of sentiment with which that doctrine was set forth by those who held it in all sincerity and taught it in all kindliness of feeling.

The theory of the trusteeship of capital, in the aristocratic politics of a century or a half a century ago, was closely analogous to the theory, in the aristocratic politics of two centuries or a century ago, of the guardianship of the upper classes over the lower.

By the latter theory it was made to appear that it did not matter how much power was intrusted to the small privileged body, since the interests of all, rich and poor, high and low, strong and weak, were so bound up together that no class or person could be injured and others not suffer thereby; and, consequently, that those most intelligent, most apt for government, having the greatest leisure for public affairs, with, moreover, the largest stake in the community, might advantageously be entrusted to make and execute all laws, their own interests restraining them from any course or action prejudicial to others, who might, therefore, safely submit to rule, in the assurance that they could not be in any way wronged or oppressed.

Aristocratic politics broke down, not because political philosophers thought better of the subject, or because the more fortunate classes desired to surrender privilege and power, but because the masses, in the fullness of time, repudiated the doctrine of a natural guardianship over them; rejected the benevolent offices of their former rulers; and, with whatever force or show of force proved necessary, asserted and vindicated their right to act for themselves, to conserve their own interests, to take part in making the laws they should obey, and in every way to be their own guardians and trustees. Aristocratic economics broke down, not because economic philosophers thought better of the subject, not because the master class invited their workmen to take part in the deliberations and decisions of industry, but because the working classes for themselves repudiated the doctrine of the trusteeship of capital; insisted upon having their wages, in full, paid into their hands, at the time; and in every way asserted their purpose to constitute themselves their own guardians and trustees. Both in politics and in economics, the instincts of the plain people proved superior to the wisdom of the philosophers, for we now know, beyond possibility of doubt, that the interests of any class are only safe when placed in their own keeping, with both the power and the disposition to assert and defend them; and that tyranny will inevitably be engendered on one side whenever helpless weakness exists upon the other.

The political revolution came first, by the necessity of the case. The industrial revolution, though it came later, was accomplished with infinitely less of strife and anguish, because the political revolution had gone before and prepared the way; had broken down the barriers which unjust laws had erected, and had in a measure educated and trained the constituencies which should constitute the industrial republic. Prior to 1825 it had been a penal offense in England for even the smallest body of workmen to combine to raise their wages or to shorten the hours of their work, while all the time masters had been free to combine to any extent to lower wages or protract the period of labor. The whole theory of the law, the whole organization of industrial society, were adverse to giving the workmen any part to perform in the distribution of wealth, the competition of the master class being held amply sufficient to protect the interests of their laborers.

Not even, when the "Combinations Acts" fell before the enlightened statesmanship of Huskisson, did the economists retract or qualify their doctrine of the trusteeship of capital. They still continued to assert that the laborer had no need to take any part, and could not to his own advantage take any part, in promoting his interests in the distribution of the product of industry. The working classes, however, had their own opinion on the subject, and, from the moment the law left them free to act, they continued to assert themselves, with increasing activity and growing confidence, though always under the grave but kindly rebuke of their professional advisers. It was not until long after the good results of their interference in industry had been demonstrated, to the satisfaction of statesmen and men of affairs, and even of the more enlightened of the master class, that the economists began to withdraw from their hopeless position, and to seek and find reasons why the laborer should, for his own interest and even for that of the community, assert himself in the distribution of the product of industry.

What are those reasons? What was the trouble with the doctrine of the trusteeship of capital? Why was not the theory of the economic harmonies a sound one?

The fatal defect in the doctrine of trusteeship of capital is found in its erroneous assumptions regarding human nature.

In it the laborer was regarded almost solely in his capacity for action, not in his recipiency, his susceptibility, his liability to deep and lasting injury. The reasoning of the advocates of this doctrine assumed that if the laborer's remuneration were temporarily diminished, he would nevertheless retain all his industrial efficiency, and that, consequently, the master would realize from his labor an excess of profits, which, in the way indicated by Profs. Cairnes and Perry, would immediately become capital and so enhance the demand for labor. Now, it would be easy to show that what is thus assumed regarding the disposition to be made of an excess of profits is not altogether true. Of any excess of profits which the employer might nominally realize, through beating down the wages of his workmen, and which he might thus be able to add to his capital, one part would not unnaturally be lost through the employer's less strenuous, diligent, and painstaking conduct of his business; another part would probably go to increase the employer's luxurious expenditure, and thus, though realized as profits, would not become capital; a third part might, not inconceivably, after becoming capital, be lost through an undue venturesomeness on the employer's part, engendered by the very fact of the excessive profits, since human nature is such that there are few men in whom the proper balance between caution and courage, between prudence and enterprise, will not be in some degree disturbed by exceptional good fortune, by undeserved success, by unearned gains.

But even were we to concede to the full the assumption that all which the workman might lose by the reduction of his wages the employer would gain; and that all that the employer might thus gain he would add to his capital, and further that the employer would apply his capital, so increased, to his business, with undiminished energy, care, and prudence, the theory in question would still be fatally defective, in that it overlooks the effects upon the laborer's will power, intelligence, and bodily strength and health which are inevitably produced by the lowering of his standard of living.

"The wages of labor," said Adam Smith, "are the encouragement of industry, which, like every other human quality, improves in proportion to the encouragement it receives. A plentiful subsistence increases the bodily strength of the laborer, and the comfortable hope of bettering his condition and ending his days perhaps in ease and plenty animates him to exert that strength to the utmost. Where wages are high, accordingly, we shall always find the workmen more expeditious, active, and diligent than where they are low." Since this is so, since the laborer's efficiency is, in large part, the immediate product of his wages, it is unjustifiable to assume that his efficiency will remain unimpaired by a reduction of his wages. But, if the laborer's efficiency is actually to be thus impaired, the excess of profits which is supposed to be brought into the employer's hands by this cause may not be realized, even in the first instance. What the laborer thus loses, the employer may not gain; and thus we may have a loss which is total and final, no economic force whatever operating to make the laborer good for his meaner subsistence, to make the employer good for having to deal with a lower order of laborers, to make the community good for the impairment and degradation of its citizenship.

If such are the possible and even the probable consequences of reductions of wages, we see at once how important it is that the laboring class should take a part, a positive and active part, in determining the remuneration of their own exertions and sacrifices in production, that is, in fixing the rate of their wages.

In dealing with the competition of employers among themselves, those who taught the doctrine of the trusteeship of capital contemplated that competition mainly as operating to raise the rate of wages, through causing masters to bid against each other for the profits of employment. But this is, in fact, only one phase of competition, and a phase which, under the conditions of modern business, is of far less importance than another, namely, that in which the master class, each for himself or in associated action, undertake, commonly from a genuine feeling of necessity, to press down the wages of labor.

No matter how high prices may be, even in the most flourishing condition of trade, it will almost always happen that a certain number of employers, in every department of production, will find it difficult to do much more than recover the wages of their labor and the cost of their materials, out of the sales of their goods. In ordinary seasons, and especially in hard times, employers of this class feel a painful necessity in some way to reduce the cost of production.

We are bound to contemplate it as a permanent condition of industry that there shall be a lower third, a lower fourth, or a lower fifth of the employers in every considerable branch of industry who, at the best, can hope to realize profits so moderate as not to exceed what the same persons might reasonably have expected to receive, as wages, if employed by others; and who are in constant danger of earning less than this, or even of sustaining a positive loss through their business operations. I am satisfied that we can no more account for the forces which distribute the product of industry without bringing into consideration the no-profits class of employers than we could explain the phenomena of rent without reference to the existence of large bodies of lands on the margin of cultivation, *i. e.*, "no-rent" lands. The relations of the subject are wide; but it is enough for our present purpose to point out that efforts on the part of this class of employers to reduce the wages of their workmen are almost a necessity of the situation, no matter what the rate of wages at the time may be, just as there is always a class of manufacturers, under a protective tariff, who feel the need of higher duties, no matter what the rate of existing duties may be.

Should the employers of the class referred to initiate a movement which should have the effect to lower wages, not only might all the consequences ensue which we have indicated, in the degradation of the body of laborers concerned, without any reparative or restorative forces of an economic character entering to correct the evil, but it is certain that those very employers would soon find themselves under the same painful pressure as before, owing to the difficulty of recovering their wages paid and the cost of their materials out of the prices of their products, now further lessened by competition. Nay, if it be true, as I believe it is, broadly speaking, that the poorer the workman, the poorer the overseer and the poorer the master, and that underpaid labor is less fully worth its wages, such as they are, than is highly

paid labor, it must follow that this tendency on the part of the less successful employers, in any branch of industry, to grind their workmen becomes stronger the further it is carried; while, on the other hand, it goes without saying that the laboring classes become weaker and less qualified to maintain their resistance, with each successive reduction of their wages and consequent impairment of their physical and moral force. It is only through considerations like these that we can explain the industrial degradation of the working classes of many countries, regarding whose laboring populations I have ventured elsewhere to say that it literally would not pay to keep cattle at all, unless they were to be far better nourished.

While the foregoing requires to be said regarding the influence exerted upon wages by the existence of a class of employers so little qualified for the conduct of business that they are always in danger of incurring loss, and can, at the best, only hope to make profits so small that we may properly term them no profits at all, being not in excess of what the same persons might reasonably look to receive as wages, if employed by others, something also, in the same connection, requires to be noted regarding the abler and more successful men of business, who do realize profits properly so called, and who may hope, in good times, to realize large profits. In the natural and proper desire to increase those profits, I believe it to be true that the first suggestion to the mind of any employer, looking to a saving in the cost of production, will be a lowering of wages; and this, not from lack of ordinary good feeling toward his workmen, but because a reduction of the pay roll is the nearest, the simplest, and the most natural mode of cutting down the cost of production. It is, in my opinion, only when the employer, even the most enterprising and energetic employer, finds that this cannot be done, that he will set himself, with due care and pains and effort, to search out other, less obvious, more remote, and more difficult modes of reducing cost. In other words, I believe that a stout resistance to the lowering of wages is the very thing needed to put the employer upon his mettle to effect those improvements in processes, those savings in the use of material, those gains in productive power through the employment of superior machines and better utensils, which, and not at all reductions of wages, are the true means of promoting the permanent growth and securing the healthful condition of any branch of manufacture.

It is from considerations like these that the economists of England and America have of late given over entirely the doctrine of the trusteeship of capital. Few writers of reputation would to-day deny that the laboring class have as real, as large, as vital a part to perform in securing an equitable and beneficent distribution of industry as have the employing class. It is seen and admitted that unless the laborers, on their side, are alert, active, and aggressive in pursuing their economic interests, immediate injuries, tending to become permanent, and tending always to go from bad to worse, are certain to be inflicted upon the whole industrial body.

So far is this view carried that it is even admitted to be for the interest of the employing class themselves that they should not exercise unrestrained power in these matters of work and wages; that it is desirable for their own sake that the natural impulse to crowd down the remuneration of labor should encounter a firm resistance, so that the competition among themselves, which is needful to keep down prices and to stimulate to the utmost activity the productive forces of the community, may be exercised by the master class without bringing, at any point, a crushing and destructive pressure upon the laboring class.

This change of economic opinion has been due partly to the greater readiness among economists to study human nature, in all its strength and in all its weakness, not less in its liability to injury than its capacity for action, which began to be manifested about the time of the second French revolution; but, even more, through the remarkable demonstration given by the working people of England of the power that resides in intelligent, patient, persistent self-assertion to raise the condition of the wage-receiving class.

Among all the chapters of human history there is not one which approaches, in its promise for the future of the race, that which tells the story of the rise of the laboring classes of Britain since the repeal of the "combinations acts," their own manful and strenuous efforts to lift themselves out of the horrible pit and miry clay in which they had been left by the long series of Napoleonic wars, being all the time assisted by a succession of moderate and judicious legislative acts, conceived in the true spirit of statesmanship, to check the greed of the master class, without destroying competition or repressing individual enterprise: acts requiring the guarding and fencing of machinery, providing for the sanitary inspection of workshops and factories, limiting the hours of labor, abolishing payment of wages "in kind," favoring the union of workingmen for beneficial purposes, and establishing special agencies for fostering the instincts of frugality and protecting the small savings of the very poor. This combination of self-help with a degree of governmental encouragement and protection carefully calculated to develop a continually larger power of self-help has furnished a model to all the nations of the world of statesmanship that finds its end in citizenship.

In all this the professional economists had no part; nay, to the full extent of their power and influence, they retarded and embarrassed the efforts of the working classes for their own advancement and of the statesmen of the empire on their behalf. In Parliament and out of Parliament, they opposed factory legislation. With the best intentions in the world, but under the domination of the *a priori* politics of the last century, they declared that combinations of workingmen to enhance their wages or to shorten their hours of labor could at the best be nugatory, and were likely to prove wholly and highly mischievous. Even so late as 1873 and 1874 eminent economists, on both sides of the Atlantic, could reaffirm the doctrine of the trusteeship of capital, in language which I have already quoted. It is in this attitude of professional economists toward factory legislation and trade unions that we find the cause of that deep distrust and dislike of political economy which was formerly entertained by the working classes, and which still in a measure animates them, although the economists of to-day are, as a body, in sympathy with the efforts of laborers to advance their condition, fully recognizing the principle that, unless they seek their interest, they must, in greater or less degree, lose their interest, with deep resulting injury to the whole community.

Such is the labor situation of to-day, as compared with that which existed at the beginning of the century. Then the working classes, held down by poverty, ignorance, and the actual force of laws which denied them any part in determining their own condition, and indeed hardly able to conceive of a better state of things, were content to leave the entire determination of the hours of work and the wages of labor to their employers; and the whole body of professional economists declared that this was wise and right. To-day the working classes stand in the attitude of having completely vindicated, not only their power to take a part in effecting the distribution of the product of industry, but also the generally beneficial influence of their active intervention in this matter.

The changed attitude of the working classes in these times should be a subject of congratulation to every lover of his kind, both because of its immediate effects upon industry and because of its ulterior social and political consequences. Yet it is one which has perils all its own. The old order at least secured industrial peace, although it was the peace of despotism, of repression, of extinguished aspirations and stolid despair. The new order brings, not peace, but a sword. When the working classes are no longer content to take passively what is offered them, without claiming a right to help decide what that shall be, or even to form an opinion what it should be; but, on the other hand, have alike the disposition, the courage, and the definite purpose to assert for themselves, at all times, the utmost economic advantage which the conditions of the market admit, holding it to be not only their right, but their duty, to have an opinion, and maintain it strenuously and persistently, as to the rates of their labor and the conditions of their employment, it will be seen that the good old days of industrial peace have gone by. With the immediate benefits and the majestic possibilities of freedom, we have to accept the dangers and the evil liabilities of personal choice and self-determination. Struggle and strife have to-day become the law of industry. To prevent or to adjust the conflicts which must arise in the modern industrial state, it is idle to talk of "identity of interests," or of the "harmony of labor and capital." These are but meaningless phrases, more likely to irritate than to soothe, when addressed to men sternly resolved to maintain what they deem their disregarded or invaded rights. Doubtless, there is an identity of interests, in the eye of omniscience; but we have to do with fallible, selfish, and passionate men, seeing but a part of the case and deeply prejudiced by their own vital concern in the decision.

Doubtless there would be complete harmony between the claims of labor and of capital were each rightly understood; but that the claims of capital, as the employer sees and is prepared to assert them, are necessarily consistent with the welfare of labor, is not true, nor is it true that the claims of labor, as the laborer sees and is prepared to maintain them, are necessarily consistent with the due increase and preservation of capital, and, hence, with the general welfare. Between the two parties there is a real opposition of interests, which may at any time be carried to the point of antagonism. This unfortunate issue is not to be prevented by crying peace, peace, when there is no peace; but by providing, as far as possible, the conditions of a fair and mutually conciliatory adjustment of differences.

The sense of the difficulties and dangers besetting the self-assertion of the laboring class, now thoroughly aroused to their own interests and conscious of their power, has led to much preaching, of late, about "the duties of capital." This phrase, conveniently vague, may be made to cover many things; but, as I understand it, two notions are in the minds of those who use it. One, that the employing class should take special pains to conciliate their laborers and win their personal favor; should cultivate their individual acquaintance, and meet them, more and more, on terms of social equality; the other, that successful employers should hold themselves bound to expend a portion of their gains in charities and benefactions among the communities constituted, in whole or in part, of their laborers. Of the first of these proposed remedies for industrial disturbance, it must be said that everything that tends to produce a better understanding between persons and classes, and to bind the members of the community together with stronger ties of mutual respect and regard, is always to be desired and welcomed. Doubtless many an employer has found, in many a strait, ample reward for special kindness and consideration bestowed in the past upon his laborers. But it does not clearly appear how it is that employers, as such, have larger duties, in this matter of cultivating personal relations with others less fortunate, than have those who are not employers, except as only their opportunities are greater through nearness and a degree of necessary acquaintance. The fact that they are employers stands already to their credit, in comparison with other members of the community, equally favored in the conditions of their lives; and they might not ineffectually reply to those who preach to them on "the duties of capital:" "We are, for our part, giving these people the means of earning their daily bread, and we are doing this with much labor and care and risk to ourselves. A division of labor is only fair. Do you entertain and amuse and instruct them?" Surely civility, courtesy, considerateness, kindness, and benevolent regard are always in order in all relationships; but I fail to see how an employer comes under any obligation in this respect which is not common to all the members of the community.

Of that which many who talk fluently of the duties of capital have in view, viz., a social *rapprochement* of classes widely separated in tastes, modes of thought, habits of living, it is scarcely worth while to speak here. It is certain that working people do not care to be patronized by duchesses or college professors or their own employers. What they want to get is as large a portion as they possibly can of the necessaries, comforts, and decencies of life; to enjoy these with their families and among their mates; to be treated always respectfully and considerately, and in distress perhaps charitably; to possess perfect equality before the law and equal rights with the richest and best; to have a fair chance to improve their own condition in life if the way opens, and to advance their children to a higher plane if these prove worthy of it. That is what the working classes want; they have no hankering for May Fair; socially speaking, they only ask to be left alone; they would much rather smoke among friends and comrades, in their shirt sleeves, than to have to put out pipe and put on coat, to receive "grand people." In the forced mingling of classes which is thus urged by well meaning people, there could not fail to be a sense of condescension on the one side and of constraint on the other.

In any event, efforts of this sort, no matter with how much zeal begun, are so certain to prove spasmodic and intermittent, that we need take little account of them in considering the labor problem of our time, which is not to be solved by lawn parties, or church fairs, or fashionable "slumming." In speaking thus of a social *rapprochement* of classes widely sundered in condition, in tastes and habits, I do not wish to be understood to express disrespect for that movement, initated in London, and more or less followed out in other cities, which may without offense be called Toynbeeism. This is an excellent thing in its way for the young men who take part in it; nothing could be better—for them. It is well, for them that they should know how so many of their fellow creatures live and work, or suffer because they can get no work. It is well that, with their kindly purposes and noble aspirations, they should see the habitations of wretchedness and the lurking places of vice. The contemplation by a generous young scholar of misery like that of the East End of London could not fail to bear precious fruit in later life. Long after the young Oxford student shall have grown gray, the recollections of a year spent among the slums of London may give directness and pathos to the sermon of the preacher or reality and earnestness to the speech of the statesman pleading for ampler protection to the unfortunate and the oppressed, or enter subtilely into the decisions of the venerable justice, appointing the penalties of wrong doing or short coming. Nay, more practical results, immediate and important, may well flow from such benevolent enterprises, in the relief of suffering, in the enforcement of religious precepts, in the administration of charity. But it is not of charity that we are now speaking; and toward the solution of the difficult questions at issue between the employing class and the great body of self-supporting, self-respecting laborers, it does not seem to me that Toynbeeism offers any important help.

As to the other notion which prompts much of the talk about the "duties of capital," viz., that employers are in some way especially bound to expend a part of their gains in charities and benefactions among the communities which are composed, in whole or in part, of their laborers, I must again confess my inability to apprehend the justice or the social reason of such requirement. Fully recognizing the duty which every man owes to the distressed or afflicted, and heartily believing that no selfish use which the rich man can make of his wealth will bring him a tithe as much pleasure as its expenditure in judicious benefactions, I am yet at a loss to see why a manufacturer who accumulates a fortune through giving employment to a thousand hard-handed and roughly clad laborers is under any greater or any other social or moral obligation to expend any portion of his gains for their benefit than is a banker or an East India merchant who has made his money with the aid only of a dozen sleek and well groomed clerks, all wearing gold watch chains. The manufacturer's wealth is his own, to spend or to keep, just as perfectly as is the banker's or merchant's. Indeed, if there were to be any question as to the benefit to the community and to the laboring class, in particular, arising from the professional lives and services of the three, respectively, it would not be the actual employer of labor who would suffer by the comparison. To bring a special claim against him for some portion of his substance to be expended for the benefit of the immediate community is virtually to assert that his profits have been in some degree obtained by robbery of his laborers, for which he is bound to make partial reparation. So much for the question of right and duty. If it be made a question of expediency, we must pass from the side of the employer and look at the matter with the eye of the laborer. How much validity is there in this notion that the solution of labor difficulties is to be effected, or at least greatly promoted, by such a use of a portion of the employer's resources as has been indicated?

In the first place, it is to be noted that there is a class of employers who could not, if they would, meet this requirement; these are likely to be the very employers who have to do, generally speaking, with those bodies of laborers who are in the hardest case. In other words, this notion of capital paying tithes, or blackmail, or whitemail, whatever it may be called, to appease the discontent of "labor," overlooks the fundamental fact that there are many employers who realize no profits out of which they could satisfy this demand; and that it is just from this body of employers that the earliest and most painful pressure comes for the reduction of wages. To look to the more successful men of business to make up by extra liberality for the inability of their brethren to perform these "duties of capital" would be as vain as it would be unjust. Here and there a wealthy manufacturer or manufacturing company may, out of exceptional generosity or public spirit, or from a prudent regard to the interests of a long future, build reading rooms and libraries, museums and picture galleries, or school houses and churches, for their little villages; lay out parks or introduce water at their own cost; pension disabled or superannuated workmen, or do other grand and liberal acts; and doubtless the result would be found in the large view as profitable as the spirit which prompted them was virtuous and honorable. Any such instance is a public blessing, whose influence extends far beyond the range of its immediate benefactions. "So shines a good deed in a naughty world." But it is too evident to need to be said, that such things cannot be relied upon to become general enough seriously to affect the relations of the two great parties in interest. The vast majority of employers must be expected to be hard-headed men, more than usually intent upon their own aggrandizement, and little disposed toward sentimentality or active philanthropy. This is, again speaking generally, a part of their qualifications for the successful conduct of business, although exceptions exist, of men who can both conduct business successfully and freely give away its gains.

Nor even, could much preaching and exhorting multiply such instances of royal liberality, on the part of employers, many fold, would this contribute much to the solution of the difficulty existing. What the working classes want is not gifts, but that which they deem justice. They want nothing in lieu of, or in commutation for, their wages. They know well enough that the aggregate value of all that they could possibly expect from the generosity of their employers would be a mere trifle compared to what they may hope to obtain by the close, unremitting pursuit of their own interests, in the distribution of the product of industry; and they are not going to be bought off in any such way. In fact, this whole notion of the "duties of capital," as signifying the liberal use of the employer's profits for the benefit of his laborers, springs out of that old, baleful root, the idea of the trusteeship of capital. It goes back to the time when the squire sought to make his farm hands forget their starving wages, by occasional gifts and perquisites of small value; when his good wife, Dame Bountiful, carried medicine and wine to the wretched tenants who were groaning in sickness directly due to the abominable condition of the cottages which neither public settlement nor the law of those days could compel the squire to render fit for human habitation. The working people of the world, generally, have become sufficiently intelligent to see through this sort of thing; and they are willing to relinquish their expectations of Christmas gifts and harvest gleanings, of soup and medicine, for the more solid advantages of increased wages and improved conditions of work. They want all their wages, all their work is worth to the employer, paid into their own hands, at the time, in ready money, and for this they will cheerfully forego every claim upon his generosity.

I have dwelt thus long upon the talk, so fashionable, about the "duties of capital," because, while too much can never be said in favor of respect and kindness between man and man and between class and class, and too high praise can never be given to any acts of public-spirited benevolence or judicious private charity, yet this preaching about the obligations of employers not only arises from a false conception of the sources of business profits and of the title of the employer to his legitimate gains, but it distracts attention from the real issues involved in industrial situation of our times.

Nor do I, for one, look upon boards of arbitration as likely to be, in any very high degree, effectual in preventing or in adjusting industrial conflicts. Social machinery can do much; but that much is little in comparison with all that is to be done to secure industrial peace. Every instance of successful arbitration is not only useful in itself, but, by its example of conciliation and honorable compromise, it becomes an educational force for the future. The virtue of this agency should be tried and proved to the utmost, and the moral support of the community should freely be given to it in every case; yet, at the best, what can be done through direct action in the way of appeals to, or negotiation between, contestants inflamed by controversy, is closely limited. The difficulty must be dealt with further back; back before the outbreak of industrial warfare; back, even, beyond the formulation of the issues out of which such warfare springs. It will not be until the working classes not only learn not to press unreasonable demands beyond measure, but come for themselves earnestly to desire not to make such demands, that the conditions of industrial peace will be supplied.

The working classes, if they would wield, without injury to the community and chiefly to themselves, the vast powers which modern conditions put into their hands, must learn that these powers are given them, not that they may do what they please, regardless of anything but their own interests, but that they may maintain their own rights, in all respect for those of others and with the most careful consideration of the welfare of the industrial state. They must learn to use the enormous strength that resides in combination and concerted action, without abusing it; it is their part to temper the proper and rightful and even necessary spirit of self-assertion, which incites them to search out every opportunity for their own industrial advancement, and to be earnest and eager in pursuing their economic interest, by so much of wisdom and of self-control, by so much of a disposition toward fairness and reasonable concession, as will lead them to seek their own good only through means which are compatible with the steady and even progress of production and with the due accumulation and conservation of capital.

It is idle to repine at the agitation, anxiety, and turmoil which have been introduced into the industrial life of our day by the rising ambition and aspiration of the laboring class, their more resolute and self assertive temper, their consciousness of power in the use of the great weapons of combination and concerted action. It is idle to wish that workingmen were back again in the state of dull acquiescence, without content as without hope, which was characteristic of the age now past. To attempt to force them back into such a state would be an act of madness. Revolutions never go backward. The "old regime" can no more be restored in the sphere of industry than in that of politics. The working classes will never have less, but always more and more to say and to do, regarding the remuneration of their labor and the conditions of their employment. Nor would any patriotic person, who clearly understands the conditions of the problem, for a moment desire that it should be otherwise. Neither the industrial nor the political republic has any longer need of subjects who submit because they must. What either republic requires is citizens who gladly obey the laws they themselves have helped to make, and who deem the public peace and the general welfare their own concern.

The problem, then, is one of education—in civics, in ethics, and in economics; of education through the schools, through the press, through labor organizations, through political and industrial debates and struggles, through all the varied experiences of life. The prospect is not an agreeable one to those who chiefly value ease and peace. As I said before, it is not peace, but a sword, which the emancipation and enfranchisement of the laboring classes has brought among us. But ought we not to rejoice that the necessity is thus laid upon us, if we would save society itself, to see to it that the whole body of our citizenship is lifted up to such a capability of prudent, temperate, conciliatory action, on matters of vital concern, as is involved in the maintenance of industrial peace?

It seldom or never happens that a community, in dead earnest and with all its might, takes up a difficult social or political problem until that problem has become so urgent that it can no longer be evaded or postponed. This matter of the education of the whole body of the people, first in letters and the elements of common knowledge, secondly in civics, ethics, and economics, has, most fortunately, as I consider it, now become a matter of pressing and instant concern, almost of life and death, to every modern state. Not because we are philanthropically interested to do it, not because we at all like to do it, but because we must, because the state of things which would result from its neglect would be intolerable, we shall take up this work and apply ourselves to it, as civilized societies apply themselves to the successive exigences incident to their growth and development; and, in so doing, we shall lift the whole body of our citizenship to a higher plane. Ought we not then to rejoice, as I said before, that so great and imperative a necessity is laid upon us? There are those who easily yield to social and political difficulties. Especially are these persons disposed to give up all hope of the republic, if industrial peace is really to be made to depend upon moderation, prudence, and self-control, upon the spirit of civility, reciprocity, and fairplay, on the part of the laboring population. Then, indeed, the state is, to them, lost. For myself, I find it less difficult to hope for good things. When I remember out of what depths of misery, by what patience, forbearance, and faith, to what a condition of self-respect and comparative industrial security, the working classes of England raised themselves, against a hostile public sentiment, against authoritative opinion, against the earnest resistance of the master class, in spite of their own misgivings and mistakes, their own errors of passion or of greed, without help, or instruction, or sympathy from most of those who should have been their friends, I see nothing in the existing situation which should discourage any one who genuinely believes in the essential manliness of men.

A NEW CHRYSANTHEMUM.

(MRS. ALPHEUS HARDY.)

A YEAR or two ago a Japanese student entered at the Harvard University received some ordinary social

CHRYSANTHEMUM MRS. ALPHEUS HARDY.

(Engraved for *The Garden* from a photograph of a flower grown in America.)

favors from Mrs. Alpheus Hardy, of Boston, and when he returned to Japan he sent her, as a slight memento of her kindness, a collection of about thirty varieties of chrysanthemums from that country, and among them was the distinct and remarkable variety shown in the engraving. The first notice of the variety was accompanied by a figure in the *Garden and Forest* for February 29, 1888 (p. 5), and this was after the plant had been exhibited for the first time at the Boston chrysanthemum show held in the month of December, 1887. It was exhibited on the first occasion by Messrs. Edwin Fewkes and Son, of Newton Highlands, Massachusetts, but very soon afterward the stock passed into the hands of Messrs. Pitcher and Manda, of Short Hills, New Jersey, and London, by whom it is likely to be distributed during the present year. As an incurved Japanese flower it is quite distinct from anything else I have ever seen, and, I was about to add, ever heard of; but it is recorded that "one Japanese kind, which the late Mr. Robert Fortune tried to bring home in 1862, was unfortunately lost on the way," and this, we are further told, "had its florets edged very beautifully with a hair-like fringe." Whether or not this lost variety of Mr. Fortune's was the one named after Mrs. Alpheus Hardy to-day does not matter, although it is by no means improbable that other distinct varieties of this now popular flower may yet exist unknown to us in the gardens of Japan or of China. The form of this variety, as will be seen by our engraving, is boldly incurved, the florets being broad, of good substance, and of the purest white. So far it only resembles other Japanese sorts recently introduced; but it differs from these and all other known forms in having the backs or outer surface of its waxy florets rather thickly set with short white hairs or downy outgrowths, admirably and truthfully represented in our figure. A microscopic examination of these hairs was made at Wellesley College by Miss Cooley, who found them formed by a glandular outgrowth of cellular tissue, and curved like the sound-holes in a violin, their tips or apices bearing a drop of yellow resin, but almost too small to be seen without a lens. The result of these hairy appendages, from a florist's point of view, is to impart an indescribable feather-like softness to the globular apex of the blooms, and we think so distinct an innovation is sure to be welcomed and grown with the utmost care and interest by most of the now numerous amateurs interested in the "Queen of Autumn." I am informed that the plant is very robust in habit and of vigorous growth, and, with many others, I shall look with much interest for home-grown flowers of it next November.—*F. W. Burbidge, The Garden.*

[FROM INSECT LIFE.]

THE HABITS OF THALESSA AND TREMEX.

By C. V. RILEY.

HABITS OF THALESSA.

OUR two largest American Ichneumonids (*Thalessa atrata* and *T. lunator*) have long been known to bore the trunks of various trees with their lengthy ovipositors, choosing apparently only trees or stumps inhabited by Tremex or other wood-boring larvæ, from which the general supposition has been that the larvæ of the Ichneumonids were parasitic upon the larvæ of the Tremex. Accurate and positive observations on this point, however, seem not to have been made, or at least not to have been recorded, prior to our own, which will presently be quoted.

Harris (Ins. inj. to Veg., p. 538) says of the larvæ of *Tremex columba*:

"It is often destroyed by the maggots of two kinds of ichneumon flies (*Pimpla atrata* and *lunator* of Fabricius). These flies may frequently be seen thrusting their slender borers, measuring 3 or 4 inches in length, into the trunks of trees inhabited by the grubs of the Tremex and by other wood-eating insects; and, like the female Tremex, they sometimes become fastened to the trees and die without being able to draw their borers out again."

It will be noticed from the above quoted passage that while Harris states positively that the larvæ of the parasites destroy the larvæ of the Tremex, he says nothing about the place where the parasitic egg is laid and does not even hazard the supposition that the Tremex larva is pierced by the ovipositor of the parasite. Later authors, however, have loosely made this statement without evidence or authority. For instance, Packard (Guide, etc., p. 196) says:

"The genus *Rhyssa* contains our largest species and frequents the holes of boring insects in the trunks of trees, inserting its remarkably long ovipositor in the body of the larvæ deeply embedded in the trunk of the tree."

Following this statement, or possibly some previous one which we have not been able to place, the idea has been current that the wood-boring larva is pierced by the ovipositor of the parasite. As late as 1886 Professor Comstock, in the Standard Natural History, II., p. 514, says:

"And the females (*Rhyssa*) are often found with their

long ovipositors deeply sunken into the trunks of such trees (infested with Sirex) in the act of laying their eggs in the bodies of the wood-boring larvæ."

From the use of the generic name *Sirex*, Professor Comstock's statement would seem to be drawn from European sources, and this has led us to make some search of European records for observation upon allied species.

Westwood (Intro., etc., II., 150) says:

"Some species, whose females are furnished with a very long ovipositor, are found on the trunks of trees, stumps of wood, etc., evidently searching for the lignivorous larvæ, in which they deposit their eggs."

Ratzeburg (Ichneumonen d. Forstins.) states that both Nordlinger and himself reared *Rhyssa persuasoria* from *Sirex spectrum*, and he also records *R. curvipes* as reared from *Xiphidria camelus*. He does not, however, give any details of his observations, nor does he state that the parasite in ovipositing pierces the wood-boring grub.

In spite, however, of the lack of definite observations on this point, the idea was almost universally prevalent among entomologists up to recent years that the parasite pierced the grub with her ovipositor and deposited her egg in its body.

In the December, 1882, number of the *Canadian Entomologist*, Mr. Frederick Clarkson gave an account of observations upon this parasite which were, upon the whole, very similar to those which we had previously made. His article was called forth by a popular review of the habits of *atrata* and *lunator* contributed to the May number of the same journal by Mr. W. H. Harrington, in which the latter fell into the old error of stating that the female Thalessa deposits her eggs in the larvæ of the Uroceridæ and other wood borers by means of her long ovipositor. Mr. Clarkson stated in brief that his experience had demonstrated that while it may be a fact that these insects deposit their eggs upon the larvæ of Uroceridæ or other borers, they do not commonly do so. In every case that he observed, the ovipositor entered through wood that had not been previously attacked, and in his opinion the egg is often, if not generally, laid regardless of contact with the larvæ. He concluded that if the Ichneumonid larvæ are carnivorous they must bore in search of food, as he thought it improbable that the adults performed the great labor of boring on the chance of meeting with a larva, but rather that they deposit eggs at every insertion.

In 1884 the question was brought up again by Mr. George Gade, of Fordham, N. Y., who had made practically the same observations as Mr. Clarkson, but who drew the strikingly erroneous conclusions that Thalesso is lignivorous and not parasitic. He is reported to have stated at the meeting of the Brooklyn Entomological Society, held September 27, 1884 (see *Bulletin* Brooklyn Entom. Soc., Vol. VII., Nov., 1884, page 103), that he had long doubted the parasitic habit of the species. He remarked:

"I have, during the past season, watched many females ovipositing, and have cut off the ovipositor when ready to be withdrawn, and in no instance have I found a larva of any kind anywhere near the point reached by the borer and where the egg was deposited. The conclusion is, therefore, that the larva is a true wood feeder, and not parasitic."

In the discussion which followed, Messrs. George D. Hulst and A. C. Weeks are stated to have announced that they had reached the same conclusion from independent observation.

At the December meeting of the Entomological Society of Washington we commented upon this report of Mr. Gade's observations, and later wrote to the editors of the Brooklyn *Bulletin* a letter which was published in the January (1885) number (page 123), giving the results of our own observation, and quoting the following letter, which we had previously written to Mr. J. A. Lintner, and which he published in an article of his own in the *Country Gentleman* for April 17, 1884 (Vol. XLIX., page 331):

"I have on several occasions had opportunity of closely studying not only the mode of oviposition, but of larval growth of *Rhyssa*. My sketches and notes are at home (written from Boscawen, N. H.), but the salient facts bearing on your question I can give from memory. In all instances where I have found the female depositing, it has been in trees infested with *Tremex columba*, and I have found her most numerous on badly affected or injured trees, or even on stumps or broken trunks already partly decayed. The instinct to reach the egg or larva of Tremex, so dwelt upon in popular accounts, is imaginary. She bores directly through the outer parts of the tree, and doubtless probes for a burrow; but her egg is consigned anywhere in the burrow; the young larva seeks its prey, and lives and develops without penetrating the body of its victim, but fastened to the exterior. This habit among parasites is much more common than is generally supposed. A great many *Rhyssa* larvæ doubtless perish without finding food, and a great many females die in probing for a burrow, especially when they burrow through wood that is sound and hard."

We also published in *Science*, November 28, 1884 (Vol. IV., No. 95, page 486), a note making the same criticism.

In the discussion which followed the reading of our letter at the November (1884) meeting of the Brooklyn society, as reported by Mr. John B. Smith, Mr. Gade announced himself as "positive that many of the logs frequented by the *Rhyssa* are not infested by Tremex or other wood-boring larvæ."

It follows from the accurate observations here brought together, and which do not depend upon inference, that Mr. Gade (as all those who support him) was entirely wrong in his conclusion that Thalessa is lignivorous; and though further observations were promised the ensuing year, we have looked in vain in the reports of the meetings of the Brooklyn society for any subsequent statement or admission of error.

We have had in our collection since 1872 alcoholic specimens of *T. lunator*, as well as *Tremex columba* in all stages, taken from the trunk of a box elder (*Negundo aceroides*) on Mr. William Coleman's farm, near Merrimac, Mo. We took these on July 4, 1872, and made notes as to the habits of the larva and pupa of both species. The tree was already partly dead, and, in fact, our experience in this, as in subsequent observations, shows that in most cases the tree has been somewhat affected, so that the wood was not firm and healthy. This stump furnished an excellent opportunity for investigation, because it was so easily split, and we examined the burrows very carefully and found Thalessa in all stages at that time—larvæ, pupæ of both sexes, and imagoes of both sexes within the tree, the larvæ being of various sizes and invariably external to the Tremex, *i. e.*, not within, but holding on to its victim and sucking the latter's life away, without in any case entering the body. At this same time females were also actively engaged in ovipositing, and by carefully tracing the ovipositor in several cases we came to the conclusion that she did not attempt to reach the Tremex larva, but only to reach its burrow, and that the young parasitic larva after hatching must instinctively seek its victim. Thalessa, therefore, is not an internal parasite, and in this it agrees with a great many other parasites, both Hymenopterous and Coleopterous, *e. g.*, Ophion, Typhia, Euplectrus, Elachistus, Elasmus, Polysphincta, Acrodactyla, Rhipiphorus, etc., which are all external, as we know from our own experience and Mr. Howard's; while Tryphon, Sphinctus, and Paniscus are mentioned by Westwood as having the same habit. In fact, external parasitism is far more common among the larvæ of the Ichneumonidæ and the Chalcididæ than has hitherto been supposed, and may be said almost to be the rule with all parasites upon true Endophytes, and with secondary parasites. The truth of the whole matter is, that Thalessa, like all other insects, is liable to suffer from fallible instinct, and that while she doubtless has better means of distinguishing a tree infested by Tremex than we have, she nevertheless often makes mistakes, and the "unerring instinct" which book entomologists are so fond of dwelling upon is often at fault. In our own experience we have never found her boring in uninfested trees, as others have done, and in cases where she fails to reach a Tremex larva and to fasten her egg upon or near it, she must either reach a Tremex burrow or a Tremex larva must come in contact with such egg or the larva issuing therefrom to insure perpetuation. The Thalessa larva no doubt actively searches for its victim within the burrow, but, from the nature of its mouth parts, is incapable of boring wood, as Mr. Harrington and Mr. Clarkson suppose.

METHOD OF OVIPOSITION IN THALESSA.

The method of oviposition in a creature with such an enormously long ovipositor as Thalessa possesses must be of particular interest. We have had good opportunities of observing it. In preparing for the act the position is generally longitudinal or in a line with the axis of trunk or branch, the head either up or down. With the abdomen raised in the air the ovipositor is taken and managed with the hind legs, and the tip guided by the front tarsi. The two outer sheaths are used as props and do not enter the wood with the ovipositor proper. They are generally crossed—a position which gives additional strength and security to them. Now, by a movement from side to side, and by arching the abdomen and bearing upon the ovipositor, she gradually forces this back through the tip of the abdomen into a membrane which issues from between the sixth and seventh joints dorsally. There is a wonderful muscular power in the anal joints, and the ovipositor is forced back until it forms a perfect coil, so that when the abdomen is stretched in a straight line to its utmost (Fig. 1, *c*) the ovipositor within the membrane makes a circle almost as large as a quarter of a dollar, the anal joint having made a three-fourths turn within the membrane. In this manner the ovipositor under the venter has been sufficiently shortened to bring its tip against the bark. During this operation, however, the outer sheaths, which have not followed the ovipositor within the membrane, have been obliged to make a more or less irregular coil opposite to and in front of the membrane, on the ventral side, as at Fig. 1, *f*. Now commences the operation of

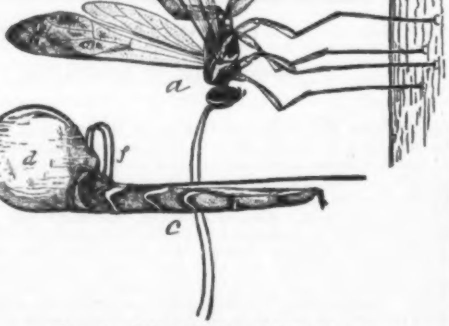


FIG. 1.—THALESSA LUNATOR.

a, female in act of ovipositing; *b*, abdomen, showing outer sheaths in slightly different position; *c*, abdomen stretched to its utmost, as when first inserting or finally withdrawing the ovipositor, and showing the coil of outer sheaths, *f*, the distended membrane, *d*, and the ovipositor coiled around inside it at periphery (original).

boring, and with the wonderful muscular power in the anal joint and the elasticity of the membrane, the insertion of the ovipositor goes on quite steadily if the wood be in the least soft. As the borer enters, the sheaths make a larger and larger loop on one side of the body, or even a valve on each side, and at last, when the borer is well nigh inserted, they present the appearance represented in *a* and *b*. Our figures, made from sketches in the field at the time mentioned, will convey a very good idea of this interesting process. In withdrawing the ovipositor the reverse action takes place and the loops of the outer sheaths gradually become smaller and smaller; the ovipositor proper is again forced back into the tough, bladder-like membrane between the sixth and seventh joints dorsally and we have a repetition of the appearance (*d*) as already described. The popular figures of the act of oviposition which we have so far seen are for the most part imaginary and erroneous. That of Rhyssa by Blanchard, for instance, is purely imaginary and shows the ovipositor inserted in a Sirex larva, while that by Wood is still poorer. The best we have seen, and evidently copied from some European work, we take from an old *American Agriculturist* (Fig. 2). The species is

FIG. 2.—RHYSSA PERSUASORIA OVIPOSITING.
(After the *American Agriculturist*.)

evidently *Rhyssa persuasoria*, which is common to Europe and North America, and which, having a relatively shorter ovipositor than Thalessa, may not require the elastic membrane. The larva and pupa of this species are figured and described by Snellen van Vollenhoven in *Tijdschrift voor Entomologie* (IV., 1860, pages 176, 177, plate 12). The ovipositor of the pupa, as is to be expected, is only about one-half as long as that of Thalessa.

Probably as good an account of the method of the boring as has been published, and one of the earliest accurate accounts, is that contributed by Mr. J. Quay to our *American Entomologist* for September, 1880 (Vol. III., page 219). We quote from this article as follows:

"As these insects, by standing on tiptoe and elevating their abdomen to its fullest height, can clear but about two inches space, the problem presents itself as to how can the remaining three inches of ovipositor be disposed of in order to allow the drill end to enter the perforated stump.

"I observed that after raising the abdomen as far as possible the drill was worked forward so as to slightly bend under, giving the insect a purchase on same. Then followed a bearing-down motion on the bent tube, curving the end of the abdomen forward and upward, and next forcing the ovipositor, near its attached end, to curve also and pass up through the abdomen and above into a cavity which there opened for its reception.

"What a strange provision of nature!

"The cavity was inclosed by a membranous sack, capable of great distension, and while the drill was being continually forced up through, it curled about within the sack, forming one complete bend of about three-fourths of an inch in diameter, and another partial one. When fully distended the sack was very thin, quite transparent, and seemingly upon the point of bursting apart. But the ovipositor was in this manner brought to the edge of the worm hole, was slipped in, and this made to ease away upon the distended sack, which, by collapsing, forced out again the drill by its mere force of contraction. The coil now soon disappeared, and the insect was fully prepared to commence operations upon the hapless *Tremex*."

(*To be continued*).

SULFONAL.

JUDGING from the clinical and other reports (*Practice*), it would seem that sulfonal is a hypnotic of unquestionable value, and that it has "come to stay." When first introduced, however, it was claimed for the drug to have no unpleasant after effects; but from recent observations in the clinic of Professor Ziemssen, of Munich, it appears that when the sleep produced by sulfonal is accidently interrupted, patients complain of a sense of fatigue, headache, ringing in the ears, and occasionally vertigo. No unpleasant phenomena result, however, if the patient is allowed to awake spontaneously.

Bearing on this subject, we note the personal experience of Dr. S. Grover Burnett (*N. Y. Med. Jour.*), who, in describing the effects of sulfonal when taken by him for insomnia, due to worry and undue taxation, says: "I took thirty grains, and in thirty minutes experienced a perfect desire for repose, being succeeded in a few minutes by wakefulness, but I fell asleep in an hour and slept for eleven hours. I awoke with dizziness, which passed away on rising, but suffered from muscular weakness to the extent that I walked with difficulty. Volition was unaffected, but my co-ordinating powers were defective, which lasted pretty much all day. The second dose was twenty grains; good sleep with the above named symptoms in less degree. Third dose, fifteen grains; refreshing sleep, but I experienced slight muscular weakness on exertion." Dr.

Burnett has also given it a thorough trial in sixteen cases of insomnia of mental diseases, and concludes that sulfonal is a reliable hypnotic in the various psychoses void of depressive states—mania, the maniacal stage of paresis, delusional insanity, etc. It is less favorable in melancholia with pronounced depression. Is contra-indicated in arteriosclerosis concomitant to a psychosis. He concludes by saying he regards it as superior to any hypnotic he has ever used when given with the same care.—*Memphis Med. Monthly.*

SOAPING GEYSERS.*

By ARNOLD HAGUE, Washington, D. C.

AT the Buffalo meeting, October, 1888, Dr. Raymond presented a paper entitled "Soaping Geysers," in which he called attention to the use of soap by tourists to cause eruptions of several of the well known geysers in the Yellowstone Park. Incorporated in this paper appears a communication received from me, written from camp in the Park, in reply to some inquiries on the subject. The letter discussed somewhat briefly the means employed by visitors to the Park to hasten the eruptions from hot springs and reservoirs of hot water, which remain dormant for days, or even weeks or months, at a temperature near the boiling point, without any display of geyser action. As the paper has called forth considerable comment, I desire to elucidate one or two points in relation to the temperature of the springs, and to answer some inquiries about the composition of the thermal waters.

In the summer of 1885, a Chinaman, employed as a laundryman for the accommodation of the tourists at the Upper Geyser Basin, accidentally discovered, much to his amazement, that soap thrown into the spring from which he was accustomed to draw his supply of water produced an eruption in every way similar to the actual workings of a geyser. Tourists with limited time at their command, who had traveled thousands of miles to look upon the wonders of the Yellowstone, soon fell into the way of coaxing the laundryman's spring into action, to partly compensate them for their sore disappointment in witnessing only the periodical eruptions of Old Faithful. Successful attempts upon this spring soon led to various endeavors to accelerate action in the dormant and more famous geysers. In a short time, so popular became the desire to stimulate geysers in this way, that the Park authorities were compelled to enforce rigidly the rule against throwing objects of any kind into the springs.

In connection with a thorough investigation of the thermal waters of the Yellowstone Park and the phenomena of the geysers, I undertook a number of experiments to ascertain the action of soap upon the waters and to determine, if possible, those physical conditions of various pools and reservoirs which permitted the hastening of an eruption by the employment of any artificial methods. This investigation, conducted from time to time, as opportunity offered, throughout the field season of 1885, included experiments upon the geysers and hot springs of the Upper, Lower, and Norris geyser basins.

The results proved, beyond all question, that geyser action could be forced in a number of ways, but most conveniently by the application of soap. The greater part of the more powerful geysers undergo no perceptible change with a moderate use of soap, although several of them may, under favorable physical conditions, be thrown at times into violent agitation. In most of the experiments, Lewis' concentrated lye, put up in one-half pound cans for laundry purposes, was employed. Each package furnished a strong alkali, equivalent to several bars of soap. In this form alkali is more easily handled than in bars of soap, more especially where it is required to produce a viscous fluid in the larger reservoirs; and, in conducting a series of experiments for comparative purposes, it seemed best, in most instances, to employ the same agent to bring about the desired results.

Old Faithful, the model geyser of the Park, exhibits such marked regularity in its workings that attempts to hasten its action appear futile. The interval between eruptions is about 65 minutes, and rarely exceeds the extreme limits of 57 and 72 minutes. After an eruption of Old Faithful, the reservoir fills up gradually; the water steadily increases in temperature; and conditions favorable to another eruption are produced under circumstances precisely similar to those which have brought about the displays for the past eighteen years or as far back as we have authentic records. The few experiments which have been made upon Old Faithful are insufficient to afford any results bearing on the question; but it seems probable that soon after the water attains the necessary temperature, an eruption takes place.

Of all the powerful geysers in the Park, the Bee-Hive offers the most favorable conditions for producing an eruption by artificial means, all the more striking because the natural displays are so fitful that they cannot be predicted with any degree of certainty. Observations, extending over a period of several years, have failed to determine any established law of periodicity for the Bee-Hive, even for three or four consecutive months; although they indicate that some relationship may exist between its display and those of the famous Giantess. Frequently the Bee-Hive will play several times a day and then become dormant, showing no signs of activity for weeks and months, although the water may stand above the boiling point the greater part of the time. The name Bee-Hive was suggested by the symmetry of the cone built around the vent. It rises about 4 feet above the sloping mound of geyserite, and, in cross section, measures about 3 feet at the top, while at the bottom of the cone the vent is less than 10 inches in width. From the top of this narrow vent it is only possible to sink a weight 17 feet before striking a projecting ledge, which interferes with all examination of the ground below. The constant boiling and bubbling of the water, the irregularity of its action, and the convenient location of the geyser, within an easy walk from the hotel, make attempts to accelerate the eruptions of the Bee-Hive most attractive to tourists.

In most instances such efforts are futile; yet success does so frequently reward the astonished traveler that, unless the geyser were carefully watched by the authorities, attempts would be made daily throughout the season. If the conditions are favorable to an eruption, it usually takes place in from 10 to 25 minutes after the addition of laundry soap or lye. It is doubtful if more than two eruptions of the Bee-Hive have ever been produced on the same day by artificial means, although I know of no reason, based upon the structure of the geyser, why more displays might not be obtained; for the reservoir and vent fill up with boiling water very rapidly after each eruption.

Although the Giantess is situated only 400 feet from the Bee-Hive, these two differ in surface and underground structure, and mode of action, as widely as any two of the more prominent geysers of the park. Around the Giantess no cone or mound has formed. The broad basin is only partially rimmed in by a narrow fringe of siliceous sinter, rising above and extending out over the deep blue water.

At the surface, this basin measures about 15 to 20 feet in width by 20 to 30 feet in length. It has a funnel-shaped caldron, 30 feet in depth, ending in a vertical vent or neck, 12 feet deep, through which a sounding lead may be dropped into a second reservoir, meeting a projecting ledge or obstruction of some kind, 61 feet below the surface.

After an outburst of the Giantess, the basin, which has been completely emptied of its water, gradually fills again to the top; and, for days before another eruption, a steady stream of hot water overflows the brim.

The intervals between the eruptions of the Giantess vary from 12 to 20 days, and the displays last several hours, being unsurpassed for violence and grandeur by any geyser in the Upper Basin. Artificial means have never been successful in bringing this geyser into action, although, for days before an eruption, it is an easy matter to cause an agitation of the water by throwing into the basin small pieces of sinter, or to produce a boiling on the surface, lasting several minutes, by simply stirring the water with a stick.

The Giant, one of the most violent of the geysers in the Upper Basin, more closely resembles the Bee-Hive than any other of those along the Firehole River. It has built up a cone 10 feet in height, one side of which has been partly broken down by some eruption more violent than any witnessed at the present day.

Through this notched side, steam and broken jets of water are constantly emitted; and on this account but little examination has been made of the underground reservoirs and vents. The Giant is fitful in its action, at times playing with considerable regularity every 14 days, and at other times lying dormant for nearly a year.

I have no positive knowledge that an eruption of the Giant has ever been produced by any other than natural causes. At the time of my experiments no eruption of the Giant had taken place for several months, although the water was constantly agitated, so much so that it was quite impossible to examine the vent with any satisfactory results. The only effect produced by the application of lye was additional height to the column of water thrown out and a decided increase in the thumping and violence of the boiling.

In the Lower Basin, the Fountain has been more carefully studied than the other geysers; and, its action and periodicity of eruptions having been fairly well ascertained, it afforded the most favorable conditions for observing the action of soap and lye upon the waters.

In its general structure the Fountain belongs to the type of the Giantess, having a funnel-shaped caldron which, long before an eruption, overflows into an adjoining basin. At the time of my experiments upon the Fountain, the intervals between eruptions lasted about four hours.

This interval allowed sufficient time to note any changes which might take place. My own experiments with lye yielded no positive results; although it seemed highly probable that action might be hastened by the application of soap or lye just before the time for an eruption, or when, for some cause, the eruption was overdue. I preferred to make the attempt to bring about an explosion before the usual time, only waiting until the water in the pool had nearly reached the boiling point. All experiments failed.

The previous year, when wishing to produce action for the purpose of photography, I was enabled to accomplish the desired result by vigorously stirring with a slender pole the water near the top of the vent connecting with the lower reservoir. In this instance, it should be said, the usual interval of time between eruptions had long since passed; the geyser was, so far as time was concerned, a half-hour overdue. My opinion now is that the experiments with lye failed because the temperature had scarcely reached the boiling point.

The Monarch, in the Norris Basin, is quite unlike those already described, and affords evidence of being a much newer geyser. It is formed by two convergent fissures, on the line of a narrow seam in the rhyolite, probably coming together below the surface. The main vent measures about 20 feet in length and, at the surface, 3 feet in width. But slight incrustation is found around the vent, the conditions not being very favorable to deposition. In this narrow fissure the water, which ordinarily stands about 15 feet below the surface, constantly surges and boils, except immediately after an eruption. The intervals between eruptions vary somewhat from year to year; but at the time of these experiments the action was fairly regular, the geyser playing every four hours. I was successful in obtaining an eruption quite equal to the natural displays, which throw a column of water 50 feet into the air. Here at the Monarch there is no surface reservoir, and the narrow fissure, filled with loose blocks of rocks around which the water is in constant agitation, prevents all measurements of depth.

The results of the many experiments, not only upon active geysers, but upon a large number of hot springs, determine fairly well the essential conditions which render it possible to bring about geyser action by artificial means. Negative results are frequently as valuable for this inquiry as experiments yielding imposing displays.

Outside of a few exceptional instances, which could not be repeated, and in which action was probably only anticipated by a few minutes in time, geyser eruptions produced by soap or alkali appear to demand two essential requirements: First, the surface-caldron or reservoir should hold but a small amount of water, exposing only a limited area to the atmosphere; second, the water should stand at or above the boiling point of water for the altitude of the geyser basin above sea level. The principal factor which makes it possible to cause an eruption artificially is, I think, the superheated and unstable condition of the surface waters. Many of the geysers and hot springs present the singular phenomenon of pools of water heated above the theoretical boiling point, and, unless disturbed, frequently remain so for many days without exhibiting any signs of ebullition. It may not be easy to describe accurately these superheated waters; but any one who has studied the hot springs and pools in the Park and carefully noted the temperatures, quickly learns to recognize the peculiar appearance of these basins when heated above the boiling point. They look as if they were "ready to boil," except that the surface remains placid, only interrupted by numerous steam bubbles, rising through the water from below and bursting quietly upon reaching the surface.

Marcet, the French physicist, has specially investigated the phenomena of superheated waters, and has succeeded in attaining a temperature of 105° C. before ebullition. Superheated waters in nature, however, appear to have been scarcely recognized, except during the progress of the work in the Yellowstone Park, in connection with the study of the geysers. The altitudes of the geyser basins above sea level have been ascertained by long series of barometric readings, continued through several seasons. In conducting a series of observations upon the boiling points of the thermal waters in the park, Dr. William Hallock, who had charge of this special investigation, determined the theoretical boiling point by noting the mean daily readings of the mercurial column. The exact boiling point of a pure surface water, obtained from a neighboring mountain stream, and the boiling point of the thermal waters from the springs, were determined from actual experiments by heating over a fire, employing every possible precaution to avoid sources of error. Surface waters and deep-seated mineral waters gave the same results, and coincided with the calculated boiling point at this altitude. Hundreds of observations have been carefully taken where the waters in the active and running springs boiled at temperatures between 198° and 199° Fahr.

As will be shown later in this paper, the thermal waters are solutions of mineral matter too dilute to be affected to any appreciable extent as regards their boiling point by their dissolved contents. The theoretical boiling point for the springs and pools in the Upper Geyser Basin may be taken at 92·5° C. (198·5° Fahr.) In many of the large caldrons, where the water remains quiet, a temperature has been recorded of 94° C. (201·2° Fahr.) without the usual phenomena of boiling. This gives a body of superheated water with a temperature at the surface of 1·5° C. (2·7° Fahr.) above the point necessary to produce explosive action. Thermometers plunged into the basins show slightly varying temperatures, dependent upon their position in the basin. They indicate the existence of numerous currents and a very unstable equilibrium of the heated waters, which are liable, under slight changes, to burst forth with more or less violence. It is under these conditions that geyser action can be accelerated by artificial means. If into one of these superheated basins a handful of sinter pebbles be thrown, or the surface of the water be agitated by the rapid motion of a stick or cane, or even by lashing with a rope, a liberation of steam ensues. This is liable to be followed by a long boiling of the water in the pool, which in turn may lead to geyser action. There is some reason to believe that, at least in one instance, an eruption has been brought about by a violent but temporary gust of wind, which either ruffled the water or disturbed the equilibrium of the pool, and changed momentarily the atmospheric pressure.

In Iceland travelers have long been accustomed to throw into the geysers turf and soft earth from the bogs and meadows which abound in the neighborhood, the effect produced being much the same as that of sinter pebbles and gravel upon the geysers in the National Park. So well was this understood that at one time a peasant living near the Iceland locality kept a shovel solely for the accommodation of those visiting the geysers.

In my letter to Dr. Raymond I mention the curious fact that the laundryman's spring, now known as the Chinaman, in which geyser action may most easily be produced by artificial means, has never been regarded by the Geological Survey as anything but a hot spring, and no one has ever seen it in action without the application of soap, except in one instance, when it was made to play to a height of twenty feet after stirring it vigorously with a pine bow for nearly ten minutes. In our records it is simply known as a spring.

If soap or lye is thrown into most of the small pools, a viscous fluid is formed; and viscosity is, I think, the principal cause in hastening geyser action. Viscosity must tend to the retention of steam within the basin, and, as in the case of the superheated waters, where the temperature stands at or above the boiling point, explosive liberation must follow. All alkaline solutions, whether in the laboratory or in nature, exhibit, by reason of this viscosity, a tendency to bump and boil irregularly. Viscosity in these hot springs must also tend to the formation of bubbles and foam when the steam rises to the surface, and this in turn aids to bring about the explosive action, followed by a relief of pressure, and thus to hasten the final and more powerful display. Of course relief of pressure of the superincumbent waters upon the column of water below the surface basin is essential to all eruptive action. These conditions, it seems to me, are purely physical. Undoubtedly the fatty substances contained in soap aid the alkali in rendering the water viscous. On the other hand, when concentrated lye is used it acts with greater energy, and furnishes a viscous fluid where soap would yield only surface suds, insufficient to accomplish any phenomenal display.

It is well known that saturated solutions of mineral substances raise the boiling point very considerably, the temperature having been determined for many of the alkaline salts. In general, I believe the boiling point increases in proportion to the amount of salt held in solution. Actual tests have shown that the normal boiling point of siliceous waters in the Park does not differ appreciably from the ordinary surface waters, mainly, I suppose, because they are extremely dilute solutions.

* A paper read before the American Institute of Mining Engineers, February, 1889.

The amount of lye required to produce a sufficiently viscous condition of the waters increases but slightly the percentage of mineral matter held in solution.

All the waters of the principal geyser basins present the closest resemblance in chemical composition, and for the purposes of this paper may be considered as identical in their constituents. They have a common origin, being, for the most part, surface waters which have percolated downward for a sufficient distance to come in contact with large volumes of steam ascending from still greater depths. The mineral contents of the hot springs are mainly derived from the acid lavas of the Park plateau, as the result of the action of the ascending steam and superheated waters upon the rocks below. These thermal waters are essentially siliceous alkaline waters, carrying the same constituents in somewhat varying quantities, but always dilute solutions, never exceeding two grammes of mineral matter per kilogramme of water. When cold they are potable waters, for the most part slightly alkaline to the taste, and probably wholesome enough, unless taken daily for a long period of time.

The following analyses of three geyser waters, selected from the Upper, Lower, and Norris geyser basins, may serve to show the composition of all of them, the differences which exist being equally well marked in the analyses of any two waters from the same geyser basin.

	Bee-Hive Geyser.		Fountain Geyser.		Fearless Geyser.	
	Grammes per kilo. of water.	Per cent. of total matter in solution.	Grammes per kilo. of water.	Per cent. of total matter in solution.	Grammes per kilo. of water.	Per cent. of total matter in solution.
Silica	0·3042	25·12	0·3315	23·69	0·4180	25·60
Sulphuric acid	0·0271	2·24	0·0195	1·39	0·0367	2·25
Carbonic acid	0·0920	7·60	0·2307	16·48	0·0046	0·28
Phosphoric acid	......	......	0·00004	......	......	......
Boracic acid	0·0145	1·20	0·0138	0·99	0·0223	1·36
Arsenious acid	0·0011	0·09	0·0027	0·19	0·0022	0·14
Chlorine	0·3894	32·15	0·3337	23·84	0·6705	41·06
Bromine	Trace	......	0·0004	0·03	0·0026	0·16
Iodine	......	......	......	......	......	......
Fluorine	......	......	......	......	......	......
Hydr. sulph.	......	......	Trace	......	Trace	......
Oxygen (basic)	0·0364	3·00	0·0654	4·67	0.0113	0·70
Iron	Trace	......	0·0002	0·01	0·0006	0·04
Manganese	......	......	Trace	......	......	......
Aluminum	0·0029	0·24	0·0057	0·41	0·0002	0·01
Calcium	0·0039	0·32	0·0014	0·10	0·0092	0·56
Magnesium	0·0002	0·02	0·0010	0·07	0·0001	0·01
Potassium	0·0213	1·76	0·0379	2·71	0·0415	2·54
Sodium	0·3118	25·74	0·3522	25·16	0·4046	24·77
Lithium	0·0061	0·50	0·0035	0·25	0·0081	0·50
Ammonium	0·00021	0·02	0·00015	0·01	0·00025	0·02
Cæsium	......	......	......	......	Trace	......
Rubidium	......	......	......	......	Trace	......
	1·21111	100·00	1·39979	100·00	1·63275	100·00

Bee-Hive Geyser, Upper Geyser Basin; date of collection, September 1, 1884; temperature, 199·4° Fah.; reaction, alkaline; specific gravity, 1·0009.

Fountain Geyser, Lower Geyser Basin; date of collection, August 24, 1884; temperature, 179·6° Fahr.; reaction, alkaline; specific gravity, 1·0010.

Fearless Geyser, Norris Geyser Basin; date of collection, August 18, 1884; temperature, 199·4° Fahr.; reaction, neutral; specific gravity, 1·0011.

The differences of temperature shown in these three waters are simply due to the varying interval between the time of collection and the last preceding eruption of the geyser. In the case of the Fountain, the water rises in a large open basin, which slowly fills up, increasing in temperature until the time of the eruption, the form of the basin permitting the collection of the water two or three hours before the next outburst. In the case of the Fearless, the surface reservoir is a shallow saucer-shaped basin, into which the water seldom rises before attaining a temperature near the boiling point. At the Bee-Hive the water only reaches a sufficiently high level to permit of its collection without difficulty when the temperature stands at or near the boiling point.

Dr. Raymond has made the suggestion that the addition of caustic alkali would possibly precipitate some of the mineral ingredients found in these waters, thereby changing their chemical composition sufficiently to affect the point of ebullition. At the same time he remarks that the geyser waters are probably too dilute solutions to be much influenced by such additions. Any one who glances at the analyses of the waters of the Bee-Hive, Fountain, and Fearless must see, I think, that they are not only too dilute to undergo any marked change of temperature, but that the mineral constituents consist mainly of the carbonates and chlorides of alkalies, associated with a relatively large amount of free silica, which would remain unacted upon by caustic alkali. There is nothing in the waters to be thrown down by the addition of alkali or permit any chemical combinations to be formed by the addition of a small amount of soap. The desire of tourists to "soap a geyser" during their trip through the Park grows annually with the increase of travel, so much so that there is a steady demand for the toilet soap of the hotels. If visitors could have their way, the beautiful blue springs and basins of the geysers would be "in the suds" constantly throughout the season. Throwing anything into the hot springs is now prohibited by the government authorities. It is certainly detrimental to the preservation of the geysers, and the practice cannot be too strongly condemned by all interested in the National Reservation.

ARTESIAN WELLS AT COOLIDGE, KANSAS.

ARTESIAN water was first discovered in Kansas by E. H. Peck on May, 10, 1887, in Coolidge, Kansas, well 289 feet deep, two veins of water in sand rock, well flowed 45 gallons per minute. This discovery created great enthusiasm, and many attempts were made in different parts of the State. About three months later artesian water was discovered in Meade County, where they now have five flowing wells of good water. Other wells were bored in Coolidge, some proving very good. After considerable study Mr. Peck determined to sink a large well, which he did. His efforts were crowned with greatest success. He struck three separate and distinct veins of water, in all amounting to about 90 feet of water-bearing strata—greater than that in any other artesian well known. This well discharges 120 gallons of water per minute, and, most remarkable of all, is one of the finest mineral waters in the United States, the following being an analysis of it by Chemist W. D. Church:

Analysis of the Water from the Peck Water Works Co.'s Well at Coolidge, Kansas.

Organic matter	0·022
Silica	0·105
Alumina and oxide of iron	0·276
Bicarbonate of lime	7·300
Bicarbonate of magnesia	3·641
Bicarbonate and sulphates soda and potash	9·969
Chloride of sodium	2·857
Total solids	24·360
Chlorine (combined)	1·740

This is a very good boiler water. It will produce only a very light, soft scale. For drinking purposes it is extra good, owing to its soft salts and freedom from organic matter. It is one of the most healthful mineral waters I ever examined. So says Mr. Church.

This well now belongs to the Peck Water Works Co., a regularly incorporated company, with $30,000 paid-up capital, with franchises from the city of Coolidge for the sole sale of water for fifty years. The water flows into 12,000 barrel reservoir, from which it is to be pumped into a stand tower 125 feet high, containing over 10,000 gallons above the 100 foot line. It has the latest improved compound duplex pumps, made by Hughes Bros. It will use both stand pipe and direct pressure system.

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TABLE OF CONTENTS.

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PAGE

1182

1187

1187

1183

1188

1176

1190

1189

1173

1184

1185

1181

1179

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eir
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